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THE

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WATER SUPPLY A SOURCE OF ECONOMY.

In 10 hours' run of a 1,000 horse-power electric station at a fairly economical average of steam consumption, the amount of feed water pumped into the boilers will be no less than 20,000 gallons, weighing 90 tons. In practice, a good deal more is often used. At 8d. per 1,000 gallons, the cost of this water will be 13s. 4d., or nearly £250 per annum. Now, to pump 1,000 gallons of water to an average height of 100 feet, demands an expenditure of almost exactly half a horse-power hour. If we double this power for pump friction and loss between the pump and the engine, we arrive at an estimate of 1 horse-power per 1,000 gallons. Allowing 2 lbs. of coal per horse-power hour at a cost of 20s. per ton, gives the fuel cost of pumping as ·214d. per 1,000 gallons. If the cost of a well and pump be placed at £100 per 1,000 gallons per hour, and the annual interest on this be 100s., the charge for interest on a period of 4,000 hours per annum will be 0·30d. per hour, and the total cost of a private water supply would be just about ½d. per 1,000 gallons. Actually, however, there is no necessity to have any but the merest trifle of fuel cost whatever. There may be even a wasteful steam engine to drive the pump, or even a direct steam pump may be employed, and the whole of the exhaust steam heat may easily be absorbed by the water as it is pumped.

As compared with the extortions of water companies, an independent supply is practically all gain. Let us take, for example, the case of the London Electric Supply Corporation at Deptford, who were using water to the tune of some £700 annually. Persuaded that an economy might be effected in this item, Mr. P. W. D'Alton entered into the question with Messrs. Le Grand & Sutcliff, of Bunhill Row, E.C., and this firm have bored an artesian well in the basement of the works to a depth of 180 feet below the floor level. The lining tubes are 6 inches diameter of steel socketed pipes, with an outer protecting pipe through the surface stratum. This well enters into the chalk, and the yield is sufficient to supply the present requirements of the works, a 6-inch hole being large enough to yield as much as 10,000 gallons per hour if the rock is of a nature to yield so much. The London basin, generally, is a favourable locality for moderate yields of water by artesian boring. With a clay extending to considerable depths, there is no surface contamination of the deep waters, and boring to the chalk in London has very little of a speculative character. The depth to the chalk varies considerably, as also does the normal water level. Thus at Deptford the chalk is met with at about 80 feet below surface, at Battersea at about 250 feet; at the Bank of England it is about 253 feet, and again, at Barnsbury, it is 190 feet—Barnsbury itself lying high. At Barnsbury, too, on account partly of the elevation of the site, the water level is about 180 feet below surface, and at

Wandsworth 76 feet, while in Bunhill Row the depth to water is 125 feet, and at Deptford the water comes within a foot or two of the basement floor, and can be pumped direct. It thus appears probable that about 100 feet may be taken as a fair average depth to water. When the water level is deep below surface, so that a surface pump cannot pick it up, it is necessary to bore an artesian well of a larger size than what is merely necessary to give the yield required, in order that a long stroke single barrel pump may be hung down the borehole as far as the water. Thus to obtain a yield of 200 gallons per hour, a pump of 6 inches diameter, and having a stroke of 18 inches, may be employed, and a hole lined with 7¼-inch tubes would be large enough to take such a pump. This size of 7¼ inches need not be continued, where expense is an object, more than 50 feet below the pump barrel, to allow of changes in the water level, and beyond that depth the borehole need not exceed 4 or 5 inches. Similarly a 12-inch pump, with a 24-inch stroke, would easily go down a hole lined with 14½-inch tubes, and would produce 12,000 gallons per hour, the lower part of the hole being, say, 9 inches diameter only.

We point this out to show the folly of throwing away large sums of money in sinking huge wells to a great depth, as though the yield of a well were dependent upon its diameter. In the spouting well sunk by Le Grand and Sutcliff for Messrs. Bass & Co., at Sleaford, no less than 30,000 gallons per hour flowed out of a 6-inch tube, under a head of 10 feet only. This is enough to show the folly of the large dug well. They are useless, dangerous, and ought to be abolished, their cost being altogether out of proportion to their yield, both in making, in pump gear, and in repairs.

In the south of London, and away north of London, the chalk gradually approaches the surface, which it reaches near Hatfield and Croydon. Wells sunk in the chalk, where this outcrops at the site of the well, yield water of greater hardness than is yielded by the London boreholes that are put down through an overlying thickness of upper tertiary strata.

The water from a boring put down last year in the York Road, Wandsworth, had a hardness of only about a third the hardness of the London water supplies, and many London wells contain appreciable amounts of carbonate of soda. Any London works, therefore, in resolving upon an independent water supply will save not merely the heavy water charges, but also considerable wear and tear of boilers and a fair amount of fuel, by reason of the great reduction in scale-forming lime salts in the feed water. Outside London proper, in the neighbourhood of Wimbledon and Tooting, the water will rise from chalk borings as much as 15 or 20 feet above the surface; it will also rise above surface along the valley of the Colne and Chess, but there are now no overflowing wells in the London area itself. Still, the cost of pumping is too insignificant to enter into account, especially where steam-power is largely used, for, as explained, the exhaust steam heat from the pumping engine can be wholly absorbed by the feed water as it is pumped. It is a good plan, also, where the engine bearings are fitted with cooling pipes and chambers, to pump the water, or some of it, *viâ* the bearings to the tanks, thus utilising any heat of the bearings to partially warm the feed water, though this latter item will be of no substantial account. Still, it is there, and, so far, valuable. The ordinary temperature of water from an average artesian borehole is about 51° Fahr. all the year round. This, though colder than a public supply in summer time, is considerably warmer in winter, when the cold water of the public supplies is often but little above 32° F. We have spoken, so far, chiefly of London, because we believe there is no electric light works or electric railway in London that is not within easy reach of a sufficient and good source of feed water, available—either as direct boiler feed or for the purpose of supplying the evaporative waste of an atmospheric condenser. But our remarks apply equally to very large areas of the country. There are, indeed, few areas where a fair supply of water cannot be obtained by boring for it, though perhaps the chalk is one of the best as regards certainty. It is, however, not the best water-yielding rock. Probably some of the Oolites, such as the Lincolnshire limestone, or certain of the new red sandstone series, yield the most copious supplies, while good supplies come also from the Permian sandstone, and from the carboniferous rocks in the North and Midlands, and in planning for a new works, the question of water should take a leading place. Often a change of site of only a few yards will make all the difference in the supply being poor or good, so much depending on the local geology and faults, which latter may sometimes determine whether a well should be sunk at one side of a house or at the other side, and may account for a couple of hundred feet difference in the final depth to be bored. Outside, as in London, it is very generally true that depths of 150 to 300 feet give best results in yield. Deeper borings are apt to be very scanty in yield, and any borehole in London put down to 400 or 500 feet, as advised by some well borers, is often a ruse for boring deeply into somebody's pocket.

One of the deepest water yielding boreholes in this country is that of Mr. Van Der Weyer, in Windsor Forest, a boring put down to obtain soft water from the Lower Greensand formation. This was found at a depth of 1,234 feet below surface, and was bored into a further 7 feet to a depth of 1,243 feet. The water rises to 7 feet above surface, or to nearly 230 feet above ordnance datum; but, though sufficient for a private supply, the supply is small, as we should expect from a very small bore at so great a depth. In making this well, Messrs. Le Grand & Sutcliff penetrated over 700 feet of chalk, in addition to several hundred feet of clays.

It is obviously impossible, in the compass of a single article, to do more than merely glance at so wide a subject as water supply from wells, for every case demands its own special consideration, both in respect of the means to be taken to secure or store a supply, as well as in the hydro-geological aspect of the site, so much depending upon the water level, the rate of yield, and the rate of demand. Still, it can safely be said that there are few places where water cannot be got, or where it will not be wise to have the subject investigated. This is all the more important in face of the very excessive charges made by water companies and the very narrow views they are apt to take of the needs of, and funds available by, manufacturers and steam users.

A few months ago, for example, the town of Wakefield, unable themselves to give an adequate supply of water to the Great Northern Railway Company, at Ardsley, obtained an injunction against the company to prevent the town of Morley from giving the necessary supply. Placed in a dilemma, the company were compelled to look about for an independent supply, and time being of importance, an

8½-inch well with a 7 inches × 24 inches pump was put down by Le Grand & Sutcliff, and, by working it long hours, this pump kept the tanks full pending the completion of a borehole of 14½ inches diameter to a depth of 200 feet, which is now supplying the whole of the water to the extensive tanks at Ardsley, watering locomotives to the extent of about 100,000 gallons daily.

In this case the boring has been made to the direction of Mr. Johnson, M.I.C.E., chief engineer to the Great Northern Railway, in the sandstones and shales of the carboniferous rocks of the Yorkshire coalfield, and the supply of water is apparently free and copious. The city of Wakefield has thus gone to the trouble of needlessly harassing the railway company in order to spite the town of Morley, and has simply compelled the railway company to defend themselves by securing an independent supply, in doing which they have also secured a great annual economy. The large borehole is carried to a total depth of 202 feet from surface, and lined with 14½-inch pipes to about 112 feet below, while 10-inch pipes are continued some 40 feet further, and perforated at the water bearing strata. The pump consists of a single barrel of gun-metal, 12 inches diameter, hung from the end of a 13-inch rising main, brought up to an outlet at the surface with a plunger to force the water to a tank about 2,000 yards distant, at an elevation of 86 feet. Thus the work of raising the water is performed, one half by the bucket which lifts it to the surface, and the other half by the plunger, the lift to the surface being about equal to that above it.

Pumps for bored tube wells are perhaps best driven by a separate engine, or by a belt from a shaft, or they may be actuated direct by a vertical cylinder on the Cornish principle. Except where the water is wanted for cooling purposes, it may often be used to absorb, not merely the heat of the steam used to drive the pump, but to condense also the steam from other engines, all which, when the water has finally to enter steam boilers, means a distinct economy.

The Telephone Service in London.

A deputation from the London County Council had an interview with the Postmaster-General on Monday last. The spokesmen showed that a responsible body like the County Council have unfortunately absorbed a great deal of the irresponsible information on telephonic subjects which was industriously disseminated a few years ago. They referred to telephone charges, and by confining themselves to citing those which just suited their purpose gave the Postmaster-General the opportunity of showing there was another side to the shield. Apart from any consideration of whether their engineer had data enough to form a reliable estimate of what telephone service could be provided for (his maximum was £10) a perusal of the report of what passed at the deputation cannot but produce the impression that the members of the Council did not know what they were talking about, and the Postmaster-General did. They were right, however, in urging that the Act of 1892 was passed in haste. We protested against that and pointed out that the probable result would be the amalgamation of the two companies with which agreements were entered into by the Post Office, but as the agreements when subsequently published showed that such amalgamation was contemplated, and apparently desired, by the Post Office, we are bound to assume that some question of policy not on the surface, and beyond our ken, was involved. We cannot regard the arrangement as altogether satisfactory, but, as the Postmaster-General says, the agreements have been entered into, and all that remains to be done is to carry them out. The Council desire to have the agreements reconsidered, and apparently to introduce some protective clauses. It is undoubtedly a question whether a practical monopoly should exist without some restriction as to charges; but however much one may desire changes it is unquestionable that the Government cannot go back on licenses and agreements formally entered into. Moreover, as we have always pointed out, the matter needs to be discussed with knowledge, and the Postmaster-General showed clearly enough that he comprehends the situation. It is more a question for the State than for local bodies. The action of the local authorities must come later.

Modern Theories of Electricity.

Prof. Henry A. Rowland contributes an interesting article to the *Engineering Magazine* on "Modern Theories as to Electricity." While admitting that no complete and satisfactory explanation can be yet given of the nature of electricity he maintains that we can now assert with certainty "that electricity no longer exists." This depends so much on how we define electricity that it might readily be either accepted or denied. That the viscous self-repellent fluid of the old theorists no longer exists goes without saying, but we still speak of quantity of electricity as forming one factor of electric energy, and the presumption is that this corresponds to some physical entity. Again, Prof. Rowland hazards the assertion that "there is nothing more certain to-day than that electricity is not a fluid." We should feel inclined to back the reverse of this assertion. Practical men have found the hydraulic analogy by far the simplest and most useful working hypothesis to explain ordinary electrical phenomena. And after the numerous changes of front that electrical theories have exhibited within recent years, we should not be surprised at some early date to find the whole army of theorists with their numerous camp followers marching straight for a fluid theory of electricity. What are the insurmountable objections to a fluid theory of electricity, and why does Prof. Rowland describe "electric current" as an unfortunate term? The only objection we can think of is Poynting's theory that electric energy does not flow through the conductor in a circuit, but through the dielectric into the conductor where it is dissipated in heat. But Poynting's theory is founded on the elastic solid theory of the dielectric, and Glazebrook has recently admitted that the elastic solid theory has failed. The steady current is, therefore, thrown back for the present into the conductor. The theory that electricity is a fluid which flows as a current through the conductor appears to have fewer objections to it than any other. It is the simplest theory and therefore the most useful to the man not overburdened with the higher mathematics. The molecules under the influence of chemical attraction may play the part of pumps at the seat of electromotive force. Prof. Rowland gives us no explanation of the origin of electromotive force, except we are to accept such unsubstantial mathematical abstractions as "lines of force." To explain electrostatic actions by the pull of contracting lines of force, and currents by motions of their ends, is like explaining gravitation by the contour lines on the maps of the Ordnance survey. Though we have taken objection to some of the more dogmatic assertions of Prof. Rowland, his article on the whole contains a very moderate and clear statement of the present state of electrical theory.

THE POSTAL TELEGRAPH COMMEMORATION.

On January 29th, 1870, the telegraph systems of the United Kingdom nominally passed into the hands of the State, the actual date on which the transfer took place being a few days later. "The Electric and International," "The British and Irish Magnetic," "The United Kingdom," "The London and Provincial," and a few minor companies, then ceased to exist. It is doubtful whether, at the present day, we fully appreciate the enormous benefits which the welding together of the various systems into one harmonious whole has conferred upon us. A quarter of a century is a period which imperceptibly forces one to forget the inconveniences suffered at its commencement, in view of the conveniences which now exist and taken as a matter of course that, any slight deviation from the smooth path is promptly taken up as an excuse to say something to the effect that "such a thing would never have existed if the old state of affairs had been allowed to exist and to develop naturally." There are many, we believe, who still hold that we should be much better served, telegraphically, had the State monopoly not been called into existence. There are many, however, who must recollect the time when to send a telegram from any town other than one served by a railway was an impossibility, and when the railway station was almost the only place from which the despatch could take place, whilst the irregular tariff was a source of great perplexity to any but the business man, and often to the latter also. The increase in message work from 6,830,812 in 1869, to 71,465,380 in 1894, is an eloquent fact, though, of course, we have no *absolute* proof that such an increase would not have taken place, or even been larger, under the old *régime*. A total of 2,932 offices in 1869, increased to 9,637 in 1894, is also a fact which speaks volumes.

It may be questioned whether the public are fully alive to the magnitude of the work required to maintain the telegraph system. Many are under the impression that once a telegraph line, with its attendant apparatus, is installed, the work is practically done, and that only on very exceptional occasions has a repair to be executed, so silently and unostentatiously is the maintenance effected. A visit to the Postal Telegraph Factory at Holloway, and to the stores at Clerkenwell (on the site of the old prison) would startle those who hold such an erroneous notion as that stated. Those who recollect the old factory and stores at Chalk Farm, and compare it with the fine factory and stores referred to, can fully appreciate the magnitude of the increase of the whole system, and the immense amount of work which has to be carried out in order to maintain efficiency. 26,764 instruments in 1894, compared with 4,045 only in 1869, and 206,304 miles of wire (representing between four and five million insulators), against 59,430 miles, is further evidence of progress and of maintenance work to be attended to.

To what extent the telegraph system may yet grow it is extremely hard to say; the fact of a heavy and apparently growing deficit having to be annually met is not an encouraging feature; but it may be questioned whether a balance of expenditure against receipts, on purely telegraphic work, is really a fair method of judging of the value of the latter; indeed, at the commemoration dinner, Mr. Shaw Lefevre, a former Postmaster-General, plainly stated that he did not consider it as such. It seems to be forgotten how intimately connected are the postal proper and telegraph systems, and how the telegraph helps to swell the volume of purely postal work. A business or other telegram nearly always starts a not inconsiderable amount of postal correspondence which otherwise would in all probability not have taken place, and we fancy that it is by no means so often that a postal communication sets the telegraph at work. So long as the telegraph was a private concern, and absolutely self-dependent, the balance of receipts and expenditure was, of course, the life of the system; but, as matters now are, it does seem that too hard and fast a line is often drawn between the two branches of the service. It is, of course, only reasonable that work done should be paid for at a reasonable rate, and that the community should not have to pay for the comparatively few. The Press rate, for example, of 1s. per 100 words is, without doubt, an unreasonable arrangement, and although it probably will have to remain unaltered, it none the less is inequitable. The lament *re* finance does not, however, come from the public, nor, indeed, does the Postmaster-General seem to express much anxiety in the matter; the Treasury officials who have to furnish the items for the Budget are those who have to do the complaining, and the system of government which makes the life of the party in power depend, to a great extent, upon taxation being not excessive, renders these complaints inevitable. If it were otherwise, the Government would only have to say: You forced us to have sixpenny telegrams by the votes of your representatives in Parliament, and if it does not pay, that is not our fault. Were the acquisition of the whole telephone system by the State a simple question of a vote in Parliament, the arrangement would soon be brought about.

WOLVERHAMPTON CORPORATION ELECTRICITY WORKS.

Some five or six years ago a private company was formed to undertake the lighting of the town of Wolverhampton, but as the corporation decided to apply for a provisional order, the company had to wind up.

In June, 1893, Mr. F. Harman Lewis (who had before held a similar appointment at Hull) was appointed electrical engineer.

A plot of land alongside the canal in Commercial Road, containing 4,066 square yards was bought at a cost of £1,928, including legal expenses. On this the station has been built, but there is plenty of room for a refuse destructor, which it is proposed to put up at some future date.

The Electrical Construction Company sent in a tender for £28,772, but by splitting up the work this was reduced to £18,762 14s. 2d., of this latter amount £1,320 being for arc lamps. Other capital items were estimated at £4,020, and the cost of buildings and contingencies, £7,228 5s. 10d., giving a total of £30,011.

Mr. Paull Brevitt, of Wolverhampton, was appointed architect, and his plans having been approved, practically the whole of the work was entrusted to local firms.

The following is a list of the contractors:—

Buildings, Messrs. Wilcocks & Co., Wolverhampton.
Boilers, Messrs. Thompson & Son, Ettingshall, Wolverhampton.
Economiser, Messrs. E. Green & Son, Manchester.
Engines, Messrs. Marshall & Sons, Gainsborough.
Dynamos, exciters, and transformers, Electric Construction Company.
Switches and switchboards, Electrical Construction Company.
Steam and exhaust piping, " " "
Cables, the Callender Bitumen Company.
Steam feed pumps (ram type), Messrs. Evans & Co., Wolverhampton.
Feed piping, Messrs. Thompson & Son, Wolverhampton.
Pumping and spare exciter engine, Bumsted & Chandler, Hednesford.
Arc lamps, Messrs. Johnson & Phillips, Charlton, Kent.
Ornamental brackets for ditto., Messrs. Johnson & Phillips.
Arc lamp-posts, Messrs. Bailey, Pegg & Co., Brierley Hill.
Accumulators, the Epstein Company.
Hand cranes (5 tons), the Bedford Engineering Company.
Ejector condenser, Messrs. Ledward & Co.
Meters, Messrs. Ferranti, Limited.
Kilowatt-hour-meters, Messrs. Oulton & Edmondson.

This constitutes the fourth example of public lighting on the now well-known high-tension continuous current substation system, the others being the Chelsea Electricity Supply Company, the Crystal Palace Electricity Supply Company, and the Oxford Electricity Supply Company. This installation is almost identically the same as at Oxford, the main point of difference being that the voltage has been doubled, current being generated at 2,000 volts at Wolverhampton.

The system may be briefly described as one whereby all the transformers in the district of supply may be controlled, stopped, or started, from one switchboard situated at some convenient central point in the district, the high-tension current being supplied from dynamos running in parallel at the distant generating station to omnibus bars on the switchboard, from which it is distributed through separate switches to the high-tension armature of each transformer. A voltmeter above each switch is connected by pilot wires to the point in the secondary network at which the low-tension armatures supply current, and the high-tension and low-tension armatures of the transformers

are connected and disconnected from the high-tension omnibus bars and low-tension network respectively, according to the number of lights in use at one time.

The generating station is by the side of the canal in Commercial Road. It is in two spans, and one end (nearest the canal) is temporarily built with corrugated iron to allow for extension. It is built to the designs of Mr. Paull Brevitt, of Wolverhampton, who was also architect of the Oxford station. The end of the bays, where they face the road, are decorated with terra-cotta tile work, the coat of arms of the town, and the words "erected, 1894," and "Wolverhampton Municipal Electric Light and Power Station." There is also a small accumulator room with acid proof floor, a workshop, stores, engineer's office, and test-room.

The concrete flooring of the station is separated from the walls by a space $\frac{3}{4}$ inch wide, and passage ways are left around the foundation stones as a further precaution against vibration, and also to be able to get at the foundation bolts.

The boilers are of Lancashire type, constructed for a working pressure of 160 lbs. per square inch, and for hand stoking. Facing the boilers are a row of coal bunkers, but the arrangements for getting the coal in are not very good. They could, however, be easily improved by knocking holes 4 feet square immediately behind each bunker and shooting the fuel in from the yard outside.

The engines are Marshall's coupled compound horizontal engines, class "G" types, there being two of $\frac{14\frac{1}{2} \text{ and } 25}{22}$ size, and one of $\frac{10 \text{ and } 17\frac{1}{2}}{24}$ size. The flywheels being 14 and 9 feet diameter respectively.

They are fitted with Proell's governor, driven from the crank-shaft by gear wheels and Renold's chain. The steam valves are a very neat modification of the Corliss valve, and, being double-beat, require very little power to work them. The exhaust valves are, as usual, at the bottom of the cylinder, but judging from the size of the crank, require a good deal of power to rotate them.

The steam pipes are of wrought-iron 7 inches diameter, with steel flanges $\frac{5}{8}$ inch thick screwed on and caulked on the outside. The bends and small pipes are of copper with gun-metal flanges brazed on. The steam pipe flanges are $13\frac{1}{2}$ inches diameter outside, and are fitted together with no less than 16 $\frac{3}{4}$-inch diameter bolts, so the joint between the flanges must either be a poor one or else the flanges are weak. The steam main forms a ring round the engine room, and is fed at three points from the boiler room main.

The exhaust pipes are of cast-iron 15 inches diameter. There is a complete system of drain pipes of galvanised wrought-iron, and McDougal steam traps.

The large valves are of the Hopkinson parallel slide pattern, and in the engine room one is placed between each engine, those which are out of reach being placed horizontal and worked by endless chains and chain wheels.

A Ledward injector condenser is provided with a centrifugal pump driven by a Bumsted & Chandler high-speed engine. The water from the canal is to be used for the condenser, but as there are a number of factories already using it for this purpose the canal gets quite warm towards evening.

The dynamos are rope driven, there being fifteen $1\frac{1}{4}$-inch ropes for each of the larger dynamos, and eight $1\frac{1}{4}$-inch ropes for the smaller size.

The two large machines are wound for an output of 2,000 volts, 70 ampères, at 400 revolutions, and the smaller one for 2,000 volts, 32·5 ampères, at 500 revolutions per minute. The armatures are Eickemeyer wound, and the commutators are 18 inches and 14 inches diameter respectively, with $\frac{1}{32}$th-inch mica between adjacent segments. These segments are clipped at each end with cast-iron rings in the ordinary standard way, the only difference being in having extra thickness of insulation. Alternate current advocates may be interested to know that no difficulty whatever has been experienced in making these commutators work with 2,000 volts across them. There are three bearings to each dynamo, each bearing being fitted with gun-metal bushes lined with white metal, and automatic continuous lubrication is ensured by means of small brass plunger pumps driven by means of eccentrics cut in the shafts.

The field-magnets are so arranged, both in the dynamos and the four lighting transformers, that the armature may be lifted out vertically.

Each large dynamo drives (by means of three $\frac{3}{4}$-inch ropes) an exciter, wound for 100 volts, 28 ampères, at 720 revolutions, but the voltage can be raised to 135 for charging the cells used for lighting the station buildings. There is also a spare exciter same as above, driven by a Bumsted and Chandler engine.

The switchboard in the generating station is divided into 10 panels, divided as follows, and fitted with the necessary switch instruments, the finish being equal to the reputation which the Electric Construction Company have earned for themselves in switchboard work:—Three panels for the dynamos; three panels for the rope driven exciters; two panels for the trunk mains; one panel for the spare exciter.

The dynamo panels are each fitted with a double pole magnetic cut-out and switch combined for 2,000 volts, and arranged to cut-out at 140 ampères or with a reverse current; the electro-magnet for this purpose being compound wound. This switch is interlocked with a double pole throw-over switch, so that the dynamo circuit cannot be closed without first making the field circuit, or, again, the field cannot be opened without first of all breaking the dynamo circuit.

The dynamos can be run in parallel, paralleling being a very easy matter, as no synchronising arrangement or artificial load is required.

The high tension or trunk mains are brought *viâ* Brunswick and Bilston Streets, across Queen Square to the basement of the Town Hall, where the central switch station is situated. They are led to double-pole switches, and then by means of omnibus bars to the transformer panels. This switchboard, which is larger than that at the generating station, is made up of the following panels:—one panel for the trunk mains; one panel for the home transformers, L.T. circuit; two panels for arc lighting; one panel for the arc lighting transformer; one panel for the accumulators and its transformer; two panels for the sub-station transformers, H.T. circuit; two panels for the home transformers, H.T. circuit.

All the metal work carrying high pressure currents is protected in such a manner that accidental personal contact with it is impossible. There is also an Aron's ampère-hour-meter and an electrostatic voltmeter.

Each of the sub-station transformer panels is fitted with a double-pole automatic cut-out and switch combined. A multiple contact starting switch and resistance of 100 ohms, in series with the transformer armature, and also a regulating switch and resistance of about 10 ohms.

The other apparatus, &c., in this station are:—

Two (lighting) home transformers, wound for 2,000 volts on primary, and 110 volts and 42 ampères on the secondary.

One arc lighting balancing motor generator, with 1,000 volts across each commutator.

One battery transformer to raise the E.M.F. to charge the accumulators.

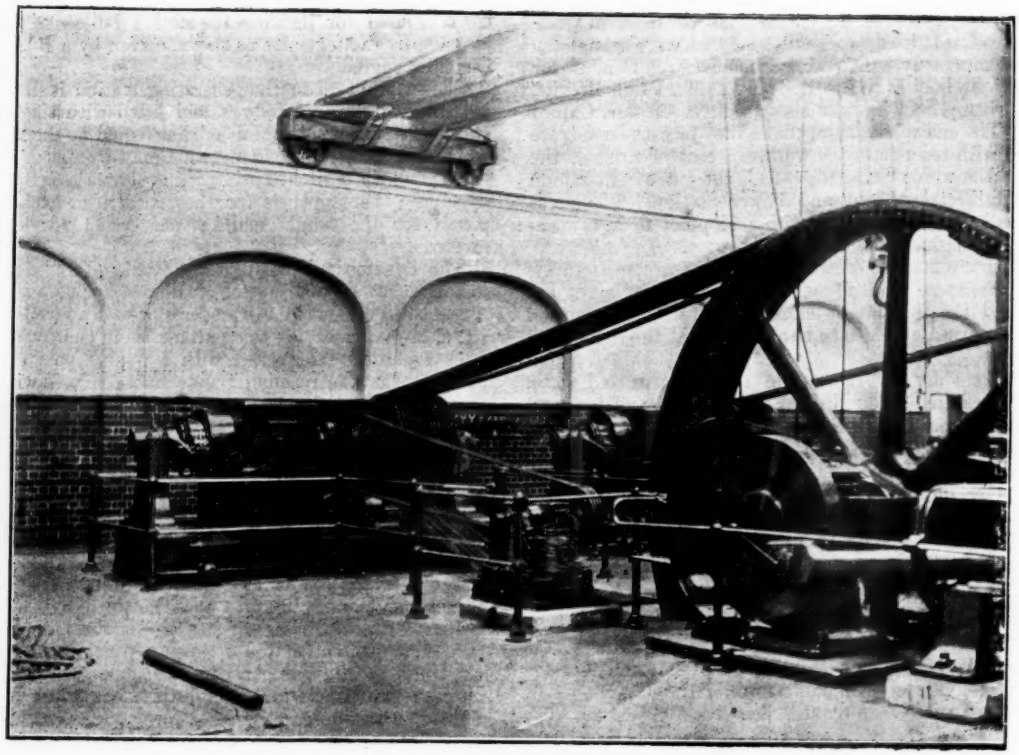
The battery transformer is run from the low tension mains, being wound for 110 volts on primary, and 40 volts, 125 ampères on secondary. The 40 volts is put in series with the network, giving a total E.M.F. of 150 volts, which is more than enough to charge the cells. By using this system there is no trouble in having to arrange the cells differently for charging and discharging.

The accumulators are of the Epstein type, and are in a room at the back of the switchboard. By means of these accumulators, the boilers in the generating station can be shut down about midnight, and thus the light loads on the machinery, which are the bugbear of every system, are got rid of.

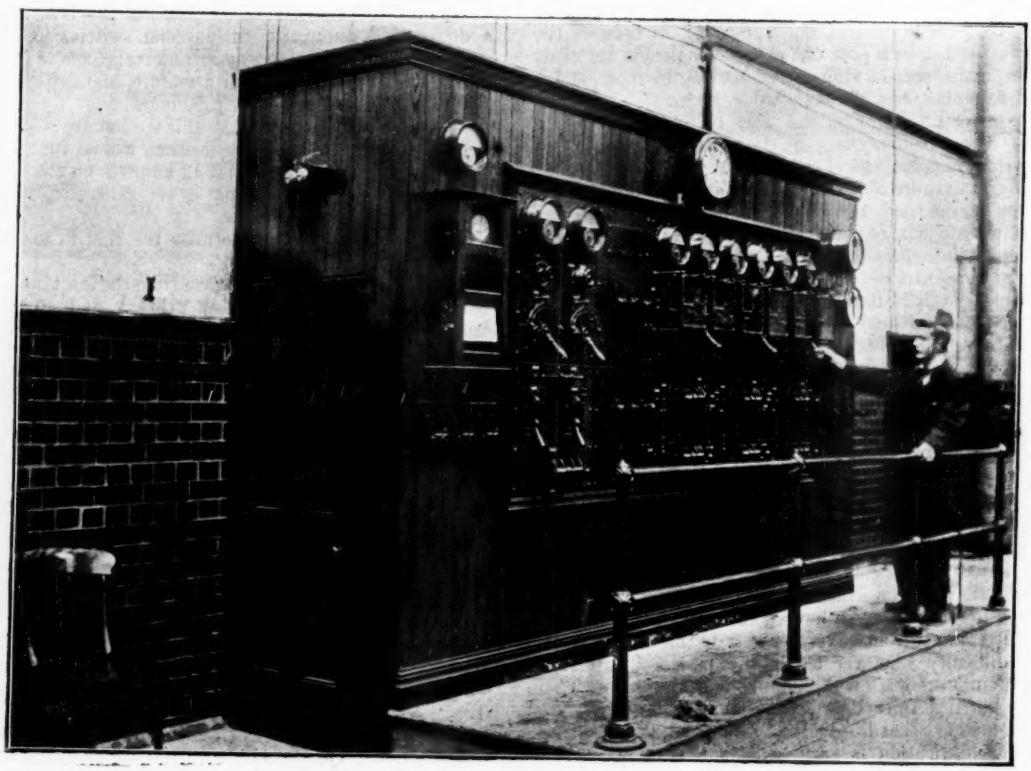
Two shifts of men can do the work that requires three shifts in an alternating station, and the saving in coal and labour is considerable.

The Central Station at the Town Hall is also a sub-station, as mentioned above, and, besides this, there are two other sub-stations, one at the Art Gallery and one at the Free Library.

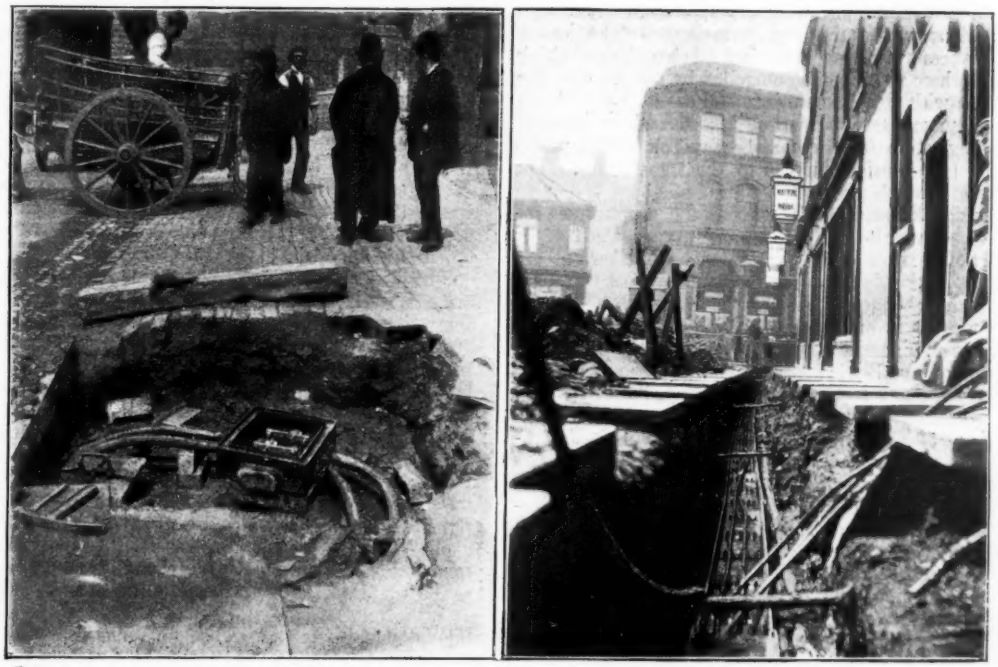
The high-tension mains from the Town Hall go along the north side of Queen Square, Lichfield Street, to the Art Gallery, and across Queen Square, along Dudley, Bilston and Market Streets, to the Free Library. Each of these sub-stations contains one 45-kilowatt lighting transformer 2,000 volts on primary commutator and 110 volts on secondary commutator, and a patent automatic distance switch,



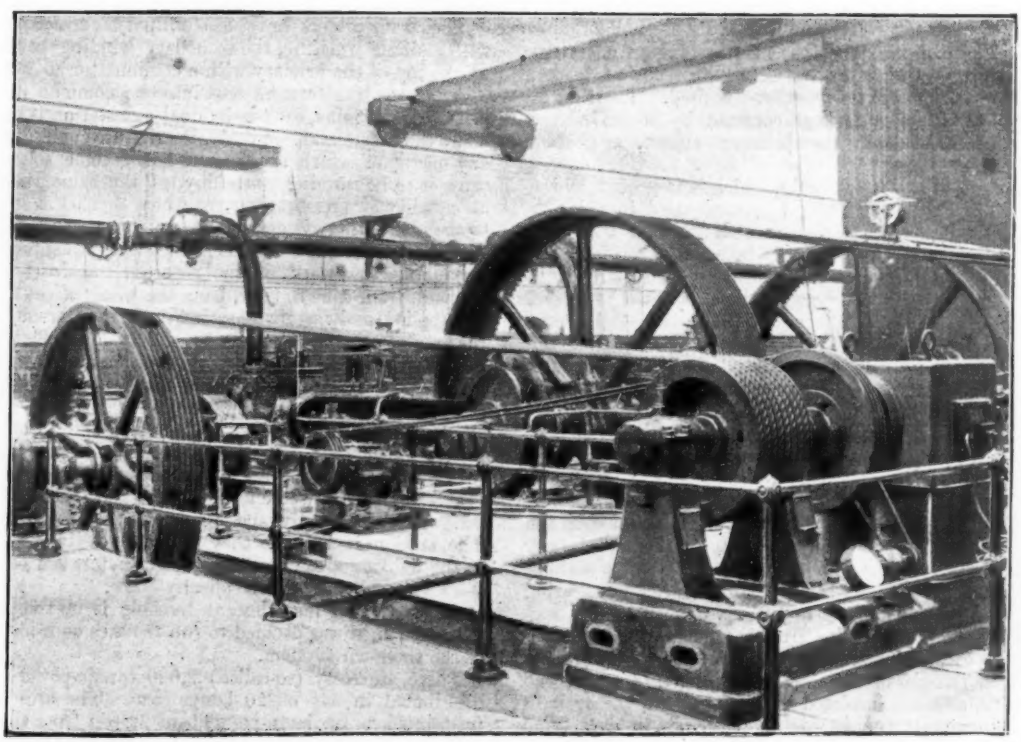
Wolverhampton.—View of Engine, Dynamo, and Exciter.



Wolverhampton.—View of Switchboard.



Wolverhampton.—Laying the Mains.



Wolverhampton.—General View.

which can be operated from the central switch station, as described below.

This switch, although rather complicated, and having a large number of wearing parts, has been found to work very satisfactorily at Oxford, and wherever it is used. Although the sub-stations where the transformers are fixed are at various distances away from the switch station, the switching in or out of these machines is controlled by one man at the above station with perfect certainty and ease. In putting a continuous current transformer on the secondary network, the first thing to do is to close the two-pole switch which conveys the high-tension current to the transformer. The current goes through a main resistance of about 100 ohms before leaving the station, passes into the armature of the machine on the high-tension side, and excites the field by means of a few turns of thick wire. The brushes on both commutators are kept permanently down, and need no alteration of lead for changes of load, as the reactions of the two armatures neutralise one another, a point apparently overlooked by Prof. Thompson when reading his paper at the last meeting of the British Association. The machine now begins to revolve as a motor with no load on, but as the iron soon reaches saturation, the speed does not go far above the normal (about 500 revolutions). The shunt winding is connected across the low tension brushes, the voltage across which can now be adjusted by means of the multiple contact switch and resistance above mentioned. Where this corresponds to the pressure at that time on the network, connection is made with the secondary armature and the mains. This is accomplished at the central switch station by momentarily opening and closing a small switch, which, short-circuiting the voltmeter, causes an increase of current to flow through a magnetic switch placed in the sub-station. The latter switch has its magnet coil always in circuit with the pilot voltmeter, the small current constantly passing being insufficient to affect this switch. When the voltmeter cable is short-circuited at the switch station, the resistance is so arranged that the full current required to operate the switch is allowed to pass through the wires and causes the magnet to ascend, and so actuates switch and completes the circuit between the low tension armature and mains. On the switch at the switch station being again broken, the magnet drops and revolves a cam wheel to a position suitable for breaking the circuit, when the magnet is again energised from the switch station; the voltmeter now reads as before, having been only momentarily short-circuited. The E.M.F. on the pilot voltmeter is kept constant by means of the regulating resistances in the primary circuit, as before explained.

When the load has fallen again, which is indicated by the pilot voltmeter, the transformer is disconnected in a similar manner. First of all the resistance is inserted until the ammeter shows that no current is being supplied from the transformer to the network, then the switch short-circuiting, the voltmeter is again made and broken, causing, as before, a quarter of a revolution of the cam wheel, which this time allows a spring to pull out the contact piece, joining the transformer to the mains. As the switch is not under ordinary circumstances broken while there is current passing, there is no sparking at the brushes, and, consequently, the switch requires no attention. A cut-out arrangement is provided so that in the event of too much current being supplied from the transformers to the mains, a magnet is raised, knocking the cam wheel round and breaking circuit, but leaving the switch ready to be worked again from the switch station. This cut-out also protects the transformer in event of the machine being placed on the circuit without the E.M.F. being properly adjusted, or in case a hot bearing should cause the transformer to pull up.

Each pair of trunk mains from the generating station is designed to carry 120 ampères at 2,200 volts. They are laid in cast-iron troughs of rectangular section, with spigot and faucet ends, and are insulated as follows: Into the troughs molten bitumen is run in for about $\frac{1}{4}$-inch in depth, and at about 18 inches interval, bridges of wood which have been well boiled in bitumen are inserted to support the cables. The vacant space around them is then filled up at several operations with melted bitumen. After it has become set the troughs are covered with cast-iron lids sealed down with bitumen at the joints.

The cables employed consist of tinned stranded copper enclosed in a solid sheath of vulcanised bitumen of the requisite thickness put on at one operation. This sheath is then firmly wound over twice in contrary directions with tape thoroughly saturated with preservative compound. Over the taping is laid a bedding of dressed yarn. The cable is then finally finished with a braiding of hemp and passed successively through baths of preservative material and of asphalte compound. The high-tension feeder mains from the Town Hall to the sub-stations are treated in the same way as above, but they are, of course, much smaller, being designed to carry only 35 ampères at 2,200 volts.

The arc lamp leads are armoured lead sheathed concentric cables, the outer conductor being formed of 20 wires laid on spirally. They are laid in the earth and the connections to arc lamp posts are made inside cast-iron boxes which are afterwards filled with heavy insulating oil.

The low-pressure distributing mains are lead sheathed steel armoured cables designed to carry 250 ampères at 120 volts, they are laid in trenches in the earth. The insulation resistance when laid complete of the whole system of distributing mains, without service line or switchboard attachments, is not less than 50 megohms between any two cables, or between any one cable and earth under a testing E.M.F. of 100 volts.

The pilot wires are lead sheathed and steel armoured, and are laid in the earth.

The lubrication of the four lighting transformers is by means of a small force pump fixed on each bearing, the plunger of the pump being worked by a small cam with about $\frac{3}{32}$-inch throw cut in the shaft. A supply of oil is contained in each pedestal, and as the oil is used over and over again the machines can be left for months without any attention. In fact, transformers have been left for six months without changing the oil. The pole pieces of these machines are also arranged that the armature can be lifted out vertically. The bearings of the smaller machines are fitted with the ordinary type of Mohler ring bearing, which gives continuous lubrication.

The high-tension commutators are excellent pieces of work, as they need to be, with 2,000 volts across them. Alternate current advocates will be interested to know that they stood the tests perfectly. The brushes are of the ordinary copper gauze type.

The transformers have the ordinary horse-shoe magnet with a single armature, the secondary winding being placed on the top of the primary with a commutator at each end.

As all the transformers feed into one common network of distributing mains, each individual sub-station is enabled to assist the others and, similarly, the rest are enabled to relieve any one upon which the demand has become so small as to cause it to be running wastefully, at the same time giving an equality of pressure over the whole district at least equal to the alternating system and in many cases superior. This system, therefore, affords the incalculable advantage of proportioning the work of the separate transformers to the demand, from time to time, from the whole of the district to be supplied, and thereby ensuring that they are all of them working at economical loads by which alone efficient transformation can be attained. In this manner it is never necessary to run any transformer with less than 50 per cent. of its full load, and as the machines are constructed to yield an efficiency of 86 per cent. at half load and 93 per cent. at full load, the total efficiency of distribution is very high. Along with the alternating system a site can be chosen for the generating station where land is cheap and there are facilities for good water supply, and an economical delivery of coal. The station is built so that it can be easily extended, and as the lighting area extends, more generators can be added to work in parallel with those already down.

Although the incandescent lighting is on the plain two-wire system, it was decided to run the arcs on a modification of the three-wire system.

There are forty (so-called) 2,000 candle-power arc-lamps distributed in sets of 20 lamps each. The arcs are hung from brackets on lamp-posts about 22 feet from the ground, and are distributed in Darlington Street, Queen Square, Victoria Street, Lichfield Street, and Queen Street.

With the Oxford system, the arc lamps for street lighting can be supplied direct from the same dynamos that supply the incandescent lamps through the continuous current transformers. In the case of the City of London lighting, and the lamps down St. Pancras Road, special arc lighting

dynamos are used; but in Wolverhampton all that is required is a small balancing transformer fixed in the central switch station.

The incandescent lamps in the Town Hall were first switched on on the 18th of January, and the arc lamps on the 19th, or about four months after the time specified for the completion of the contract. Lord Kelvin, who presided at the dinner of the Wolverhampton Chamber of Commerce on the 30th of January, took advantage of his visit to the town to perform the formal opening ceremony.

Applications representing nearly 5,000 8-C.P. lamps have been made.

Wolverhampton.—Laying the Mains.

Cost of Generating Station, Sub-Stations, Mains, &c.

	£	s.	d.
Buildings, Commercial Road	5,000	0	0
Three boilers, complete, and setting with two feed pumps, &c.	2,410	0	0
Three engines, dynamos, &c.	4,804	0	0
Steam exhaust, drain pipes, and valves	758	15	0
Condenser...	253	0	0
Switchboard, complete	300	0	0
Overhead crane in engine room	187	10	0
Water softener	150	0	0
Accumulators	150	0	0
	£14,013	5	0

Town Hall Sub-Station.

Buildings	150	0	0
Switchboard complete	435	16	0
Four transformers and three spare armatures ...	1,369	0	0
Accumulators	410	0	0
Stores, meters, &c.	300	0	0
	£2,664	16	0

Free Library Sub-Station.

Buildings	100	0	0
Transformer and switch	432	10	0
	£532	10	0

Art Gallery Sub-Station.

Buildings	150	0	0
Transformer and switch	432	10	0
	£582	10	0

Mains complete	5,700	0	0
Arc lamp-posts and brackets	211	15	0
Arc lamps	553	10	0
Extras and sundries	500	0	0
	£6,965	5	0

Note.—Service line connections not included in mains.

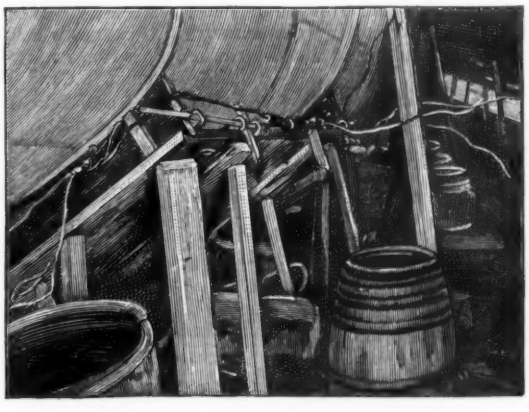
Total Cost of whole Undertaking.

	14,013	5	0
	2,664	16	0
	532	10	0
	582	10	0
	6,965	5	0
Arc lamp, double and single arm carriers	260	16	9
	£25,019	2	9

THE ELECTROPLATING OF THE HULLS OF IRON SHIPS.*

Paints and compositions innumerable have been tried to prevent marine growths from forming upon iron and steel vessels below the water line. Mr. Theodore D. Wilson, late chief naval constructor, says: "Thousands of dollars have been expended in the testing of protective and anti-fouling paints and compounds with very little encouragement to further experiments." The process of Mr. Thomas S. Crane, of East Orange, N.J., patented May 30th, 1893, controlled by the Ship Copper Plating Company, of New York, has just been put to a practical test in coating the iron hull of an ocean tug 98 feet long with copper to the thickness of $\frac{1}{20}$th of an inch. The tug is being treated in a dry dock in Jersey City, but it is expected to coat new ships before they are launched, to save the expense of docking and loss of time.

The destructive effect of barnacles on the hulls of the ocean liners and war vessels is well known. Some idea of the saving in cost by using the new process may be gained from the statement of Philip Hichborn, the U.S. naval constructor, in his report to Congress, in which he says that to dry dock, clean, and paint the cruiser *Chicago* in any port would cost about $12,000, and that on the average it would be necessary to do this three times a



year, making $100,000 for a three years' cruise. Only a short time ago one of our war ships burned 1,000 tons more of coal on her homeward trip from Rio than on her journey there, and her speed was two or three knots less per hour because of a foul bottom. From the hulls of the *Alert* and *Atlanta* 25 tons of barnacles and incrustations were removed. Some of the foreign navies resort to the cumbersome method of covering the vessels with planking, which is in turn

* *Scientific American.*

sheathed with copper. A coating of copper will keep barnacles off the hulls, and will also prevent the pitting and corrosion to which iron and steel vessels are now subjected.

By the new process, which we illustrate, the copper is electrically deposited in sections upon the surface of the vessel in successive rows, and the joints of the sections are overlapped during the electro-deposition in such a manner as to perfectly unite the whole coating of the vessel. The entire surface below the water line, including the riveted laps of the steel sheets, the keel, the stern and rudder post, are thus protected by an unbroken metallic sheet of copper. The baths are open upon one side, which is applied to the hull of the vessel, and our illustration shows the bath actually applied to the hull of the tug *Assistance* while supported upon blocks in the dry dock.

The method is a triple one. The bath, which in size is about 5 feet square, is securely placed in position, and after being shored up against the vessel's bottom, is calked around the edges with cotton and oakum till it is watertight. Then it is filled with strong acid solution for 24 hours, which cleans the plates. The acid bath is removed, the spot washed thoroughly, then the wooden bath is filled with a solution of copper cyanide, and a current of 6 volts and 900 ampères is applied. The action of the cyanide solution is two-fold; it assists in cleansing the plates, and also causes a firm film of copper to adhere in the next stage of the process. The cyanide bath is removed after having been allowed to act for 24 hours, and a solution of copper sulphate is substituted. Large copper plates are used as anodes; the current is reduced to 3 volts, and the ampèrage remains the same.

The deposition of copper takes place immediately, and the process continues until copper has been deposited to the thickness of $\frac{1}{20}$th to $\frac{1}{16}$th of an inch; the current is then stopped, and the bath removed. The deposition of the copper usually requires about four days. The coating is closely adherent, and cannot be removed except by chipping with a cold chisel, in which case a portion of the iron usually comes away with it. The lapping of the coatings has been already described. There is no chance for galvanic action to set in, except by a blow, or grinding upon a rock, which might cut through the film. But after such a blow the vessel would undoubtedly have to be docked for repairs, and a small bath could be applied to re-copper the defective spot. The plating of propellers will be of particular value, as the least bit of corrosion interferes seriously with their efficiency. Of course, in practice, a large number of tanks or baths would be in use, and it is expected that an ocean steamer of the largest size (600 feet long) could be completely plated in four weeks.

Experiments have been made on the copper coating, using sea water which has been brought from 10 miles out at sea; it is found that this water has no effect on the coating. To Mr. Henry Bergfels, the plater of the tug, much credit is due in the way of overcoming difficulties which naturally arise in a new undertaking of this description. It is now expected that an elaborate plant will be built to accommodate vessels of a large size, if the *Assistance* proves to be all right in actual sea trials. The success of the plating stage of the process is assured, and all that is now needed to demonstrate the success of the process as a whole is a test in actual service, to see if the coating has the permanency which there is every reason to believe it possesses.

Our engraving is from a photograph showing one of the electroplating baths in operation, as applied to the bottom of the tug *Assistance*, as above described.

SOME TESTS ON BORCHERS'S BATTERY.

By R. P. FUGE.

As there appears to be considerable difference of opinion as to the merits of this battery, the following tests were made by the author to ascertain the origin of the electromotive force and its value. He thinks they may be of interest to others besides himself. The solution of cuprous chloride was made in all cases by dissolving cuprous oxide in an excess of hydrochloric acid, the resulting liquid being an acid solution of cuprous chloride.

The Latimer Clark standard cell having given unreliable results, due to a bad contact inside the cell, a Leclanché cell was used in these experiments, as a standard of electromotive force, its electromotive force being taken as 1·6 volts. The electromotive force to be measured was in each case ascertained by charging and discharging a condenser through a Kelvin reflecting galvanometer. The deflections obtained are given below, together with the electromotive forces calculated therefrom.

The first experiment made was to ascertain if air by itself influenced the electromotive force. The apparatus employed is shown in fig. 1. C_1 is a solid carbon, and C_2 a carbon bell

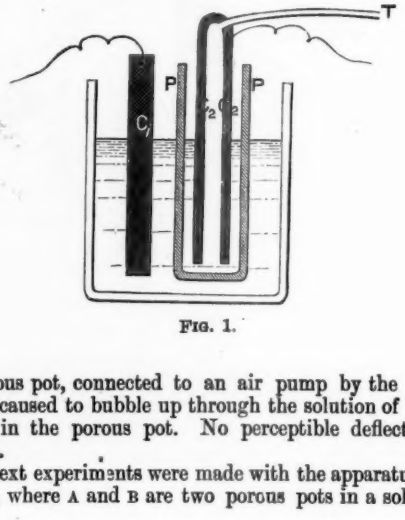


Fig. 1.

in a porous pot, connected to an air pump by the tube, T. Air was caused to bubble up through the solution of cuprous chloride in the porous pot. No perceptible deflection was obtained.

The next experiments were made with the apparatus shown in fig. 2, where A and B are two porous pots in a solution of

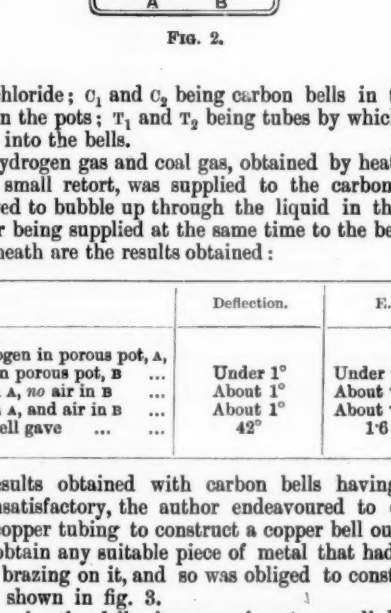


Fig. 2.

cuprous chloride; C_1 and C_2 being carbon bells in the same solution in the pots; T_1 and T_2 being tubes by which gas can be forced into the bells.

Pure hydrogen gas and coal gas, obtained by heating coal dust in a small retort, was supplied to the carbon bell, C_1, and allowed to bubble up through the liquid in the porous pot, A, air being supplied at the same time to the bell, C_2.

Underneath are the results obtained:

	Deflection.	E.M.F.
Pure hydrogen in porous pot, A, and air in porous pot, B ...	Under 1°	Under ·038 volt.
Coal gas in A, *no* air in B ...	About 1°	About ·038 volt.
Coal gas in A, and air in B ...	About 1°	About ·038 volt.
Standard cell gave	42°	1·6 volt.

The results obtained with carbon bells having so far proved unsatisfactory, the author endeavoured to obtain a piece of copper tubing to construct a copper bell out of, but failed to obtain any suitable piece of metal that had not the marks of brazing on it, and so was obliged to construct the apparatus shown in fig. 3.

Air was in the following experiments supplied to the carbon bell, C, at a constant pressure of $1\frac{3}{4}$ to 2 inches of

water, and was occasionally forced to circulate in the liquid, though doing so did not make any appreciable difference in the results.

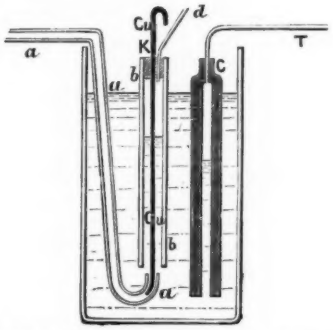
The tube, *a*, was supplied with carbonic oxide obtained by heating potassium ferro-cyanide and sulphuric acid; the gas so obtained was allowed to bubble up through the tube, *a*, into the glass tube, *b*, round the copper wire, and was allowed to escape through the aperture at *d*, the size of which was so regulated as to produce pressure of the CO of about 1 inch of water in the top of the tube.

The vessel was filled with an acid solution of cuprous chloride, as before.

	Charge deflection.	Discharge deflection.	Mean deflection.	E.M.F. in volts.
Standard cell	41	43	42	1·6
No air in carbon bell and *no* CO round the Cu wire ...	17	18	17½	·66
No air in carbon bell, but CO supplied to circulate round Cu wire	15	14	14½	·54
Air supplied to carbon bell, and CO supplied to circulate round Cu wire ...	15	14	14½	·54

The last column represents the electromotive force in volts between the Cu wire and the carbon bell in each experiment, from which it will be seen that the result of the admission of CO to the solution round the copper wire was apparently to lower the electromotive force, and that the admission of air to the carbon bell made no appreciable difference in the electromotive force.

It therefore follows that the origin of the electromotive force in the Borchers cell is the chemical action between the solution and the copper. To still further test the matter, the copper wire in the arrangement shown in fig. 3 was carefully cleaned and weighed, and found to weigh 2 dwts. 2 grains. The cell was then short-circuited for one hour and a quarter, its electromotive force (on open circuit) being measured every quarter of an hour. Underneath is given the results:—



c is the carbon bell to which air is supplied by tube, T; Cu is a copper wire going through the cork, K, down into the tube, *a*; *a* is a glass tube to supply carbonic oxide; *b*, glass tube round Cu; *d*, a small tube in cork, K, by which escape of CO is regulated.

Fig. 3.

Time.	Charge deflection.	Discharge mean deflection.		E.M.F. in volts.
7.15 p.m.	15	14	14½	·54
7.30 „	11	12	11½	·44
7.45 „	11	11	11	·43
8. 0 „	10	10	10	·38
8.15 „	9½	9½	9½	·36
8.30 „	9½	9	9¼	·35

The copper wire was now again, after being washed and dried, carefully weighed, and found to weigh 2 dwts., showing, in one hour and a quarter, a loss of 2 grains, due to the chemical action of the solution on the copper.

This result shows conclusively that the energy in the Borchers battery is entirely due to the chemical combination of the copper with the electrolyte.

In the next experiment a copper rod, weighing 2 dwts. 3 grains, was placed with a carbon wire in an acid solution of cuprous chloride, and the two were then short-circuited for 14 hours. The copper wire, though only dipping 1 inch in the solution, was now found to weigh 1 dwt. 22 grains only, having therefore lost 5 grains in weight, while a similar piece of copper wire hanging in the same solution, but not joined to the carbon, only lost 1 grain in weight, showing that a solution of cuprous chloride, though it does not very actively act on copper, yet, when copper is employed as the anode in a battery cell in which carbon is used as the cathode in a cuprous chloride solution, the cuprous chloride acts most energetically on the copper.

ARGON: THE SUPPOSED NEW ELEMENT IN THE ATMOSPHERE.

The large, distinguished, and unprecedented meeting of the Royal Society, on January 31st, received the paper on "Argon: A New Constituent of the Atmosphere" with enthusiasm, and although so many eminent personages were there, the absolute failure of the faculty of criticism on that occasion forms one of the most curious episodes in the history of the Royal Society of London.

The facts as up to the present time disclosed by Lord Rayleigh and Prof. Ramsay are as follows:—The weight of a litre of atmospheric nitrogen at 0° C. and 760 mm. barometric pressure is 1·2572 grammes. The weight of a litre of nitrogen derived from nitre or ammonia is 1·2505 grammes. The theory by which Rayleigh and Ramsay seek to explain this difference of 6·7 milligrammes between the weights of atmospheric nitrogen and of the nitrogen derived from nitre, is that the presence of argon in the atmosphere is the cause.

Let us now see how far the experimental evidence bears out this theory. Argon, say its discoverers, is heavier than the nitrogen of nitre, the relative weights of equal volumes of argon and nitrogen being 20 and 14. That is to say, one volume of argon weighs very nearly as much as one and a half volumes of nitrogen. Now, in order that the excess of density of atmospheric nitrogen over nitre-nitrogen may be accounted for, the amount of argon in atmospheric nitrogen must reach 1 per cent. by volume. Indeed, in strictness, a little more than 1 per cent. is demanded. According to Rayleigh and Ramsay, metallic magnesium possesses the property of combining with nitrogen at a bright red heat, and of refusing to combine with argon; and by taking advantage of this property, Rayleigh and Ramsay have brought out a method for the preparation of argon from air. In their paper they give instructions how to prepare argon by that method, and (what is more to the point), an example indicating the yield. They seem to have operated upon 100 or 150 litres of air, or, rather, of air from which the oxygen had been removed by red-hot copper in the well-known manner. In the actual experiment (the details of which they publish), the yield of argoniferous nitrogen was about 1,500 c.c., which, of course, would be about 1 per cent. of the original atmospheric nitrogen. But now comes the remarkable fact: on further investigation, this 1½ litre did not turn out to be, approximately, pure argon. It was not even strongly argoniferous; it dwindled down to 200 c.c. on further treatment with metallic magnesium, and the 200 c.c. had a sp. gr. of 16·1, instead of 20, showing that only 70 c.c. was real argon. Thus actual experiment indicates that the real proportion of argon in the air is only about 0·05 per cent. by volume; and we are driven to the conclusion that the difference of density between the nitrogen of the air and the nitrogen derived from nitre cannot be explained by the existence of argon in the air in the small proportion indicated by the actual extraction of the argon.

Chemists, with much practical experience in original research, always attach importance to *the yield of the new substance*; and in cases where, as in the present instance, the yield of the new substance is only about one-twentieth of that which the theory requires, are inclined to regard the whole investigation with suspicion. The very existence of argon is at present in doubt, and will remain in doubt, until the extraordinary failure of yield has received satisfactory explanation.

THE CANNON STREET EXPLOSION.

Report of an Inquiry held by direction of the Board of Trade under the provisions of Section 37 of the City of London Electric Lighting Orders, 1890, as to the cause of an Accident which occurred in the City on November 10th, 1894.

To the Assistant Secretary, Railway Department, Board of Trade.

Sir,—I have the honour to report that, in accordance with the instructions of the Board of Trade, I have held the inquiry detailed above.

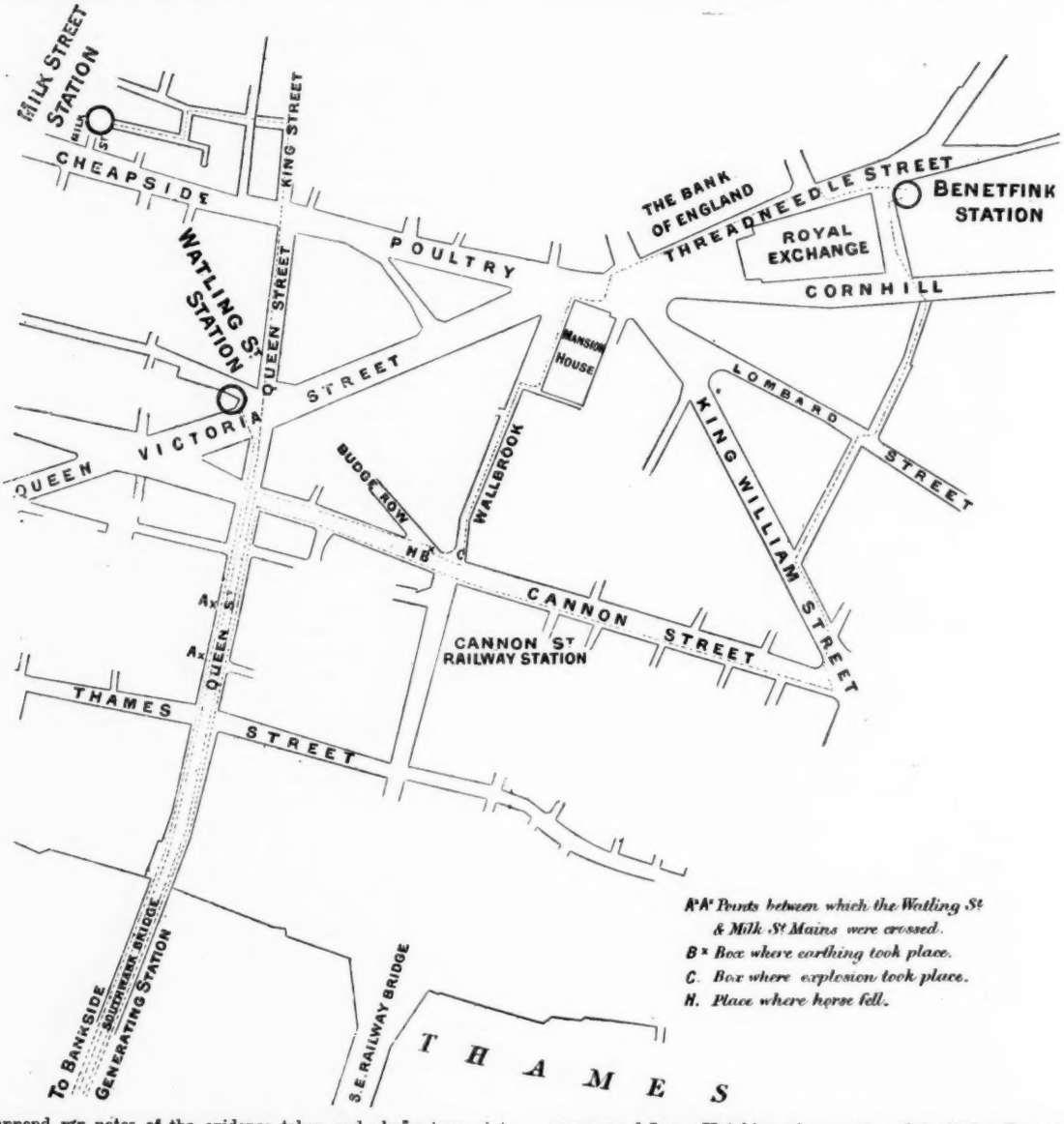
This inquiry occupied three days, the 19th, 20th and 23rd inst. Mr. W. Russell Griffiths appeared for the Aldermen and Commissioner of City Police, Mr. E. A. Baylis for the Commissioners of Sewers, and Mr. R. W. Wallace for the City of London Electric Lighting Company. These gentlemen rendered great assistance in elucidating all the facts material to the inquiry.

The supply has until lately been given from two generating stations, one at Wool Quay near the Custom House, and the other at Bankside on the south side of the river. The stations were only intended to provide temporarily for the lighting, and a large permanent station has recently been constructed at Bankside, and partly equipped with plant and machinery.

The operations connected with the transfer of the load to the permanent station were being carried out at the time the accident occurred.

General Account of Occurrences.

It appears that on the 10th ult., about 1 p.m., a mare attached to a brougham belonging to Mr. C. Boutland, of 21, Cousin Lane, Thames Street, E.C., was turning out of Cannon Street into Budge Row, when she pitched forward on her knees, then turned on her side, and died in about four minutes. The driver, G. Clark, got down, and immediately felt an electric shock in both legs. He was unable, on account of the intensity of the shock, to touch the mare, but disconnected the traces and backed the brougham clear. A warehouse-



I append my notes of the evidence taken, and also a transcript from the notes of the shorthand writer employed by the City authorities.

Twenty-nine witnesses were examined, of whom 17 were present at the time of the occurrence, several of these having suffered injury and electric shock. The other witnesses were various officials of the company and experts. Among these latter Mr. Foulger, chief distributing engineer of the Gas Light and Coke Company, gave very valuable evidence. I have also prepared a diagram showing the positions of the principal points referred to in this report.

Description of System.

It will be of advantage to shortly describe the system of supply in use by the City of London Electric Lighting Company, Limited.

This consists of a high pressure alternating current supply by means of concentric mains to converting stations, which, as a rule, have been constructed underground, and from these a low pressure supply is given to consumers by distributing mains.

man, named James Hutchins, who was at work in Budge Row, went to assist, but he also experienced a severe shock, and was unable to approach the mare closely. Shortly afterwards the iron lid of the street box opposite the Liberator Building Society's office was lifted about 2 feet in the air by an explosion, and thick smoke issued from the box. According to one witness there were three reports, each accompanied by a flash of blue flame. This street box is the one marked B. Two witnesses received severe shocks by stepping on to the street box cover on the opposite side of Budge Row.

Apparently simultaneously with the explosion in Budge Row, a more serious explosion occurred at the street box at the corner between Walbrook and Cannon Street, west side. In this case the lid was blown sufficiently high to be shattered by its fall, and the paving stones in the vicinity were also dislodged. Several persons were injured by this explosion; in most cases the injuries received were only trifling. Two persons, however, I was informed, were unable to attend my inquiry on account of the injuries they had received.

The veterinary surgeon who made a *post-mortem* examination of the mare, stated that all her organs were perfectly healthy, and he could not account for her sudden death, otherwise than as a result of severe electric shock.

The immediate causes of these serious accidents were:—The breaking down of the insulation of a high pressure main in the street box at the corner of Budge Row, leading to the formation of a powerful electric arc between the outer conductor of this main and the end of the iron pipe, forming a conduit for the mains under Budge Row, which projected into this street box, and the consequent charging of this pipe to a dangerous extent; and the presence of gas in the electric light company's pipes and street boxes to an amount which formed a highly explosive mixture in the street box at Walbrook where the more serious explosion occurred, the gas being fired by the electric arc.

It is true that Mr. Foulger, on behalf of the gas company, informed me that since the accident they had tested the soil in the vicinity of this street box, and had not detected the presence of gas in it, but, on the other hand, expert evidence was given of the actual presence of a highly explosive mixture of gas and air in a neighbouring street box, connected with it by means of several pipes, on the 19th inst. No gas was detected in the box where the explosion occurred at this test, but the cover of an intermediate box was loose at the time, thus providing a means of escape for the gas.

On the whole, considering the nature of the explosions, the fact that one of them occurred at a distance of 26 yards from the electric fault, that the locality was admitted to be one where defects in gas pipes had been rather frequent in consequence of the disturbance of the subsoil by the excavation for the completion of the Inner Circle Railway, and that no system of ventilation had been provided by the electric light company for their conduits, there can, I think, be no doubt that the explosions were due to the firing of an accumulation of gas in the conduits by the electric arc formed at the point where the main broke down.

The breakdown of the main was the consequence of a careless mistake, whereby an abnormal electrical pressure was brought upon the outer conductor, and this pressure found a point of weak resistance, probably a partial abrasion of the insulation, where the main was bent to enter the pipe leading from the box.

The existence of mechanical injury to the insulation is almost a necessary postulate, since a piece of main containing the fault, now in my possession, shows the insulation to have been of ample thickness and first class quality, and it should easily have withstood the maximum pressure to which it was on this occasion subjected. Indeed, I am informed that it had been tested with a much greater pressure.

The mistake that was made was as follows:—Two new mains had recently been laid, one from the generating station at Bankside to Watling Street converting station, the other from Bankside to Milk Street converting station.

It was intended to connect the Watling Street main into the new switching apparatus provided for it at Bankside, but the end of the Milk Street main was put in by mistake, while the end of the Watling Street main was left lying on the outer lead coating of another new cable. The end of this main was prepared to be put into its switch pillar and was not sealed up, as otherwise it should have been, and the inner conductor must have been very nearly in contact with the lead coating, and thus, by means of the iron rack in which the cables were lying with the lead coatings of several other cables, all of which coatings were thoroughly connected to earth.

While the Watling Street main was lying in this position, instructions were sent to the foreman of the transformer department, Mr. Joseph McMahon, to switch the pressure on to it from the Watling Street converting station. As soon as he did this, an electric arc started at Bankside between the end of the inner conductor of this main lying as above described and the lead coating adjacent to it, thus effecting a connection of the inner conductor of this main, and of the whole system of mains, to earth.

Now, in a concentric system of mains used for the transmission of alternating currents, under normal conditions the outer conductors are very nearly at the potential of the earth, and practically the whole working pressure exists between the inner conductors and earth. But a connection to earth of the inner conductors tends to reverse this condition, and raises the pressure between the outer conductors and earth.

The inner conductor of the Watling Street main may have been absolutely touching the lead coating or "dead to earth" when first charged, and in this case the pressure between outer conductors and earth would have been raised to the full 2,000 volts at which the station was working. When the arc started in the street box in Budge Row, however, the pressure would be probably nearly equal on the inner conductors arcing to earth at Bankside and the outer conductors arcing to earth in Budge Row.

This breakdown occurred in full daylight, so that the load on the station was comparatively light, and the sudden increase of current was at once noticed at Bankside, both by the powerful disturbance it caused in the telephone at which the engineer in charge of the station happened to be at the time, and by the peculiar noise, indicative of a short circuit, made by the generating machines.

Some of these generating machines were at once switched out of circuit, and the abnormal load thrown upon the only two machines left running, caused such a lowering of pressure on the whole system, that the lights are said to have gone out altogether.

The foreman at Watling Street Station noticed a flickering of the lights shortly after he switched the new main on, and suspecting that his action had in some manner occasioned a fault, he at once switched it out of circuit. This was certainly the best thing he could have done, but it did not remove the fault, since the electric arc in the Budge Row street box had, of course, rapidly burnt away the insulation between the two conductors of the main, and established an arc, or short circuit, which still continued to burn furiously, melting away a considerable amount of both conductors.

The engineers at Bankside in the meantime, after consultation, determined to switch off mains in succession until the fault was discovered, and by this means the fault was removed from the circuit.

Explanation and Comment.

Having thus given an outline of the occurrences, I will now deal more particularly with the points in which I consider the company and their officers and employés were to blame for want of judgment, carelessness, and inattention to the regulations imposed by the Board of Trade, and with the manner and means by which any repetition of such an alarming and serious accident may be avoided:—

1. In the first place, it will naturally be asked, How was such an egregious mistake committed as the charging of one main under the impression that it was another? Bearing in mind that the pressure was one dangerous to life, it is evident that the consequences of such a mistake might easily have been fatal, since the end of the main that was charged might have been in a man's hand at the time?

2. Why, when the breakdown had occurred, since it certainly occasioned an excessive current in the mains affected, were these mains not automatically cut out of circuit?

3. Why, in the absence of proper automatic disconnectors, were there not, at any rate, some indicators to show the disturbance of potentials with regard to the earth and the rush of current through the mains affected; and how far might such indicators have prevented the breakdown, or shortened the duration of the dangerous condition?

4. How was it that the surface of the street at Budge Row could become so dangerously charged in consequence of any defect in the electric mains; and how can this danger be removed?

5. Why was not the high pressure main in the street box enclosed in strong metal casing efficiently connected to earth as required by Regulation 7, *vide* Appendix III., since this box also contained low pressure conductors?

6. Why was the accumulation of gas allowed to which the company attributed the explosion, and which they have themselves proved to exist in a neighbouring street box since the explosion?

1. The facts elicited at the inquiry with regard to this point disclose, in my opinion, great negligence on the part of some of those concerned. It appears that the two new mains to the Milk Street and Watling Street converting stations respectively run side by side down Queen Street. The pipes to contain these mains had been laid some time previously, but the mains themselves were drawn in between October 9th and November 7th, some delay having occurred during the progress of the work owing to the cables not being ready, and to alterations in one of the street boxes. The mains are drawn into the pipes in lengths extending from one junction box to the next, the ends of each length are labelled to correspond, and the jointers subsequently effect the necessary joints at the junction boxes.

Owing, probably, to some obstruction met with, the pipes between two junction boxes in Queen Street were, to some extent, twisted round each other, so that their ends occupied different relative positions at the two boxes.

The two mains were drawn in at the same time according to Mr. A. Cook, the superintendent of cable laying, and probably, in consequence of the twisting of the pipes, either the labels were wrongly applied on the ends of the cables at one side of one or the other of these junction boxes, or the jointers jointed ends marked "Watling Street" and "Milk Street" together.

There is a direct conflict of evidence on this point between the foreman in charge of the laying and jointing respectively, but I do not think it is necessary that the Board of Trade should inquire too minutely into the question of the exact proportion of blame to be borne by the various subordinate officials of the company.

The main fact is admitted that between this point and Bankside Station, and in the station itself, the main to Watling Street was labelled Milk Street, and *vice versâ*.

It is not, however, so surprising that such a mistake should have occurred, considering that the mains were laid and jointed up at the same time, and that the engineer in charge had not apparently given very close personal supervision to the work, as that one of these mains should have been charged to high pressure and connected into an electrical circuit, the electromotive force in which was maintained by large engines and dynamos amounting to over 1,500 horse-power, without previously identifying the main, that is to say, ascertaining by the very simplest electrical test—a test thoroughly understood by every telegraph linesman's assistant—that one of the cables brought into Bankside was in connection with the cable in Watling Street Station, and which of the two it was.

This blunder appears to have been partly due to a misunderstanding between the superintendent of cable-laying and the electrician in charge of testing, but principally, I think, to the latter having made a report that the Watling Street cable was good, without having ascertained that the rough test of insulation, which was the only test he had taken, had been really applied to the whole cable.

Had he taken the precaution to test this by directing the distant ends of the main to be connected together so as to pass a current through the circuit thus formed, the wrong labelling of the two mains would have been at once discovered.

It also appears to me that in a matter of so much importance the superintendent of cable-laying was too easily satisfied that the main was correct when he knew that only a rough test had been made, and that he might with advantage have been present when the main was switched on.

2. The answer to this is that the fuses inserted with the object of providing an automatic means of cutting any main out of circuit in the event of a breakdown required much too large a fusing current to be an effective protection, more especially since under the system of

cross-connection of converting stations at present in use, the fault will draw current from each end of the main so that only a proportion of the current which is doing the mischief passes through either fuse.

In this instance the main which broke down in Budge Row was protected at each end by fuses calculated to act with 700 ampères passing, and it was practically impossible for the generating power running at the time to actuate them.

The reason alleged for the use of such large fuses is that up to the present time the whole supply has been given through a few mains, and any failure in one of these mains would throw an excessive load on the others. Fuses calculated on the normal maximum load for each main would, therefore, be insufficient to carry the increased working current in such a case, and a total stoppage of supply might result.

Since, however, the maximum current intended to be carried by any one main is only 150 ampères, I consider that the fuses used were far too large, even from the point of view that continuity of supply was the first consideration.

The proper proportioning of fuses does not appear to me to have received due attention. The guiding principle seems to have been to take care that they were so large as not to cause inconvenience by acting.

It is at times of light load that large fuses fail to act, and I am of opinion that it would be a desirable precaution on all large mains used for high pressure supply to use a small fuse for light loads, and switch in a larger one before the time of heavy load. Of course a reasonable margin must be allowed for possible unforeseen demands for current, and inattention might cause some trouble, unless the switching in of the large fuse could be provided by automatic means, but the small fuse might be arranged to give warning when the current began to exceed its capacity.

While on the subject of fuses, I would direct attention to the omission on the charging of the new Watling Street main of a very simple precaution, which had it been taken would certainly have prevented the accident, viz., to charge the new main in the first instance through a fine fuse wire.

Had this been done the moment the arc started at the other end of this cable, the pressure would have been cut off.

3. The observation of the potentials, with regard to the earth, of the two sides of an electric supply circuit is rarely provided for by electric light engineers, although it is a very important precaution, more especially in the case of high pressure systems.

Where the mains consist of separately insulated conductors, the occurrence of any fault of insulation is at once detected by the effect produced on their potentials, and the insulation resistance of the whole circuit can be obtained at any time without any stoppage of supply being necessary for purposes of testing.

In the present case, where the mains are concentric throughout, and where the potential of the outer conductor should always remain nearly the same as the earth, any rise of potential on this conductor must indicate a fault and a dangerous condition of the circuits.

Such a rise of potential must have occurred before the breakdown in Budge Row took place, and it is probable that if a simple indicator of such rise had been fixed at Watling Street station, and if the foreman there had been warned that it was an indication of danger, to be observed when any unusual operation was in progress, the accident would have been avoided.

Then again, as regards the current indicators:—

It appears from the evidence that the engineers at Bankside were quite in the dark as to where the unusual current was passing, and they had to resort to the expedient of switching off mains in succession until they discovered which were affected.

Valuable time would have been saved had there been a current indicator for each main to refer to.

I do not, however, wish to press this point too hard, as the new switch-room at Bankside was at the time in an incomplete state.

The evidence of the station engineer is that the faulty cable was cut out in 13 minutes, the recording voltmeter curves show a duration of 15 minutes. I think, with suitable indicators and prompt action, it might have been cut out within one minute, and had this been done the explosion would not have occurred, and possibly even the death of the horse might have been avoided.

4. The charging of the surface of the ground, resulting in the death of a horse and shocks to human beings, was brought about in identically the same way as in the case of the accident at Bournemouth on January 8th last, referred to in my report dated January 20th, 1894.

Here again there was a short length of iron pipe (about 37 feet in this case, 32 feet in the Bournemouth case) terminating at the brick walls of the junction boxes at each end, and not in metallic connection with the iron pipes on the other sides of these boxes. The depth of the pipe below the street level varied from 1 foot 4½ inches to 2 feet 6 inches (about 18 inches in the Bournemouth case). In this case it is true that the surface of the street was wood pavement, which might be supposed to offer considerable resistance to the passage of an electric current, but the weather had been unusually wet for some time before the occurrence, and the wood blocks and underlying concrete were no doubt thoroughly saturated with water, and their resistance thereby diminished.

Since the Bournemouth accident I have carried out, with the assistance of the Instructor in Electricity at the School of Military Engineering, Chatham, some experiments to determine the rate of fall of potential on the surface of the ground produced by charging a pipe under similar conditions. The results of these experiments are detailed in a joint paper communicated to the Royal Society, and published in their *Proceedings*. They fully confirm the view I took of the nature of the Bournemouth accident, which has been repeated in this case. The cause of the fatal shock to the horse, and of the comparative immunity of human beings, is fully stated in the report and paper above referred to.

To remove this particular danger, the whole system of iron pipes enclosing high pressure mains must be thoroughly connected together, and additional precautions, which are detailed below, should be taken to prevent any possibility of a discharge from mains to pipes.

The duty of providing against this danger is distinctly imposed upon the company by Regulation 8, *vide* Appendix III., and they should not have permitted short lengths of pipes containing high pressure mains to remain isolated.

5. I consider that there was a distinct failure to comply with Regulation 7, and I had previously brought this matter to the notice of the company.

It had also been brought to their notice by the engineer to the City authorities.

It happened that in this case the low pressure conductors did not become dangerously charged, and they do not even appear to have been damaged either by the electric arc or the explosion, but the strong metal casing would probably have protected the cable against injury to the insulation, and even in the event of a breakdown, would have much reduced the chance of accident, by making a metallic connection from pipe to pipe across the street box. If an arc had been formed at all under these conditions, it would have been a much smaller one, and time would have been given to cut off the pressure before the arc had eaten its way through the metal of the casing, or for the fuses to act, had they been sufficiently sensitive.

The company now propose to encase the high pressure mains across all street boxes by wrapping them with several layers of stout copper strip, continued into the pipes at each side, and this precaution alone will, in my opinion, considerably reduce the risk of similar accidents.

6. The question of the accumulation of gas in the conduits and street boxes of the Electric Lighting Company is the most difficult to deal with of all the questions raised by this accident.

The danger is a well recognised one, and Regulations 14 and 15, *vide* Appendix III., impose upon the company the duty of efficiently protecting their conduits and street boxes against such accumulation. That this duty had not been adequately performed had been forcibly demonstrated by several previous explosions. One of these, the double explosion on January 8th last, was investigated by me, and the Board of Trade called the attention of the company to the fact that they were not adequately complying with regulation 15.

The company thereupon informed the Board of Trade that they were maturing a scheme of ventilation for their conduits.

At this inquiry, however, it appeared that no means of ventilation had as yet been provided.

What has been done is to keep two men constantly employed inspecting street boxes, and reporting any accumulation of gas. These reports have been forwarded to the Gas Light and Coke Company, and in many cases the information thus supplied has enabled leakage of gas to be detected. Since the accident the number of men employed in opening street boxes has been increased to 12.

It certainly appears that up to the time of the occurrence of the recent accident the company had not displayed sufficient vigour in dealing with this very important matter, but it must be admitted as some excuse that there is at present some diversity of opinion as to how, in cases where the soil is heavily charged with gas by leakage from the gas pipes, it can be best prevented from accumulating in the conduits of the electric lighting companies.

Thus, at the present inquiry, Mr. D. Cook, on behalf of the electric lighting company, gave particulars of a scheme of thorough ventilation which they were prepared to adopt, while Mr. Foulger, who appeared on behalf of the Gas Light and Coke Company, stated that, in his opinion, this system of ventilation would be dangerous, and Major-General Webber gave it as his view that the pipes and conduits should be plugged at each street box to prevent percolation of gas, thus making thorough ventilation impossible.

The company have a very extensive network of pipes occupied with their own mains, and they have also numerous spare pipes laid in communication with the same street boxes, and intended, I understand, to accommodate telephone wires. The whole length of their pipes and conduits exceeds, I am informed, 700 miles.

In my opinion, a system of thorough ventilation of all street boxes by natural or forced draught should be provided, and, in addition, everything possible should be done to prevent the entry of the gas by making the sides and bottoms impervious.

Also the air capacity of these boxes should be reduced where practicable, by filling them with incombustible material.

At the same time, the system of regular inspection should be continued, and immediate notice of any leakage of gas detected given to the gas company, who appear to take a very reasonable attitude in the matter, and expressed through Mr. Foulger their desire to render all the assistance possible towards the prevention of any further explosions.

In the provision of ventilating pipes, it will be necessary to consider the possibility of the ignition of the gas issuing from these pipes. If they are attached to houses, they should in all cases be carried up above all windows, and if they are erected in the streets, the orifice should be at least 8 feet from the ground.

So far I have dealt with the immediate causes of the accidents and the mistakes made, but it is, I think, desirable, also, to draw attention to the fact that the work of the officials of this company has been lately carried out under very difficult conditions.

The company commenced business with two so-called "Pioneer" stations, and have erected, and partially equipped, the new generating station at Bankside, in order to be able to efficiently meet the rapidly increasing demand for electric light.

In this station nearly the whole of the plant and equipment is of novel design and unusual size and power, and the difficulties met with in the thorough testing and adjustment of this must naturally have been considerable.

Before, however, the station was completed, before much of the

plant had even been erected, still more before it could possibly have been thoroughly tested, and the adaptation of each part for its required action sufficiently studied by those who were to use it, the work of supplying electric energy to the City of London was thrown upon the new station.

The whole of the operations connected with the transfer of the load had to be carried out without interfering with the continuity of the supply, and at the same time the system of distribution mains was largely added to and remodelled.

It is certain that in this transition stage risks were run, risk to the apparatus, risk to the employés of the company, and, as has been practically demonstrated, risk to the public. Here, I think, we have the real element of danger, which may, if not properly guarded against, occasion even more serious accidents. The same unfortunate experience has been the fate of other electric lighting companies.

More especially are companies using a high pressure system liable to become involved in the difficulties of a transition stage, since they are able to start with a very small capital expenditure, and yet carry the supply over a large district, picking up a customer here and there, while with low pressure this is impossible.

Requirements.

I will now summarise the precautions which should be taken by the company to prevent a recurrence of the accidents which form the subject of this inquiry.

1. In the first place, greater care is necessary in the testing and identification of new cables before connecting them to the high pressure system.

2. Every new cable should be connected to the charged system in the first instance through a fine wire fuse, to be kept in circuit for at least two hours before any working current is passed through the cable.

3. Prompt action of the safety fuses should be secured by properly proportioning them to the working currents, and, if found practicable, by the use of more sensitive fuses at times of light load.

4. The interconnecting mains between converting stations should be kept out of circuit, except where in any case they may be absolutely necessary to maintain the supply, so that in the event of a breakdown of a main, current shall not be supplied to the fault from both ends, thus rendering the action of the safety fuses uncertain.

5. Suitable indicators should be provided at the generating and converting stations of the current passing in each main and branch connection, and especially of the pressure between the outer conductors and the earth, unless the company prefer to provide against the possibility of this pressure becoming large under any conditions by making an efficient connection of all the outer conductors to earth at the generating station. Of course, this can only be done with the approval of the Board of Trade, with the concurrence of the Postmaster-General. This approval has been already obtained by the London Electric Supply Corporation, and several other companies using concentric cables.

Such an earth connection seems, so far, to have had no ill results, and it is certainly of great value in the interests of the public safety.

6. All high pressure mains, where they pass through street boxes, should be enclosed in strong metal casing extending to some distance into the pipes at each side, so that the whole length of main shall be enclosed within metal which is in connection with earth throughout its length.

7. Accumulation of gas should be prevented by thorough ventilation, by making the sides and bottoms of street boxes impervious to gas, and by filling up the boxes as far as practicable with incombustible material.

8. Finally, while the company's arrangements for generation and distribution are still in a transitional stage, and while new and untried apparatus has to be brought into use, the very greatest care, and the closest possible supervision, are necessary. There is, I think, reason to hope that the company have now nearly completed the task of getting their system into proper working order, and if the precautions I have specified above are thoroughly carried out, I do not consider that there will be any further cause for anxiety as regards the public safety.

I have, &c.,
P. Cardew, *Major.*

December 4th, 1894.

Appendix III.

Extracts from the Regulations for securing the Safety of the Public, &c., made by the Board of Trade under the provisions of the Electric Lighting Acts, 1882 *and* 1888, *and of the City of London Electric Lighting Orders*, 1890 *and* 1891.

(7) Where any high pressure conductor is laid in a subway, or in the same conduit with any low pressure conductor, it shall be completely enclosed in strong metal casing efficiently connected to earth.

(8) Where any high pressure conductor is laid within a less distance than 18 inches from any low pressure conductor or from the surface of the ground, or where any low pressure conductor is laid within the above-mentioned distance from any previously laid high pressure conductor, efficient means shall be taken to render it impossible that the low pressure conductor or the surface of the ground shall become electrically charged by any leakage from or defect in the high pressure conductor.

(14) Every conduit for conductors constructed in streets in which gas mains are also laid, shall be efficiently protected against an accumulation of gas.

(15) Where a street box contains any high pressure conductor, efficient means shall be taken to render it impossible that the cover or other exposed parts of the box, or any adjacent material forming the surface of the street, shall become electrically charged whether by reason of leakage, defect or otherwise; and every street box shall be efficiently protected against any accumulation of gas or water, and its cover so secured that it cannot be opened except by means of a special appliance.

THE EUSTON ROAD EXPLOSIONS.

Report of an Inquiry into the circumstances connected with two explosions which took place in the electric light conduits in the Euston Road, on December 29th, 1894.

To the Assistant Secretary, Railway Department, Board of Trade.

Sir,—I have the honour to report, that in accordance with your instructions, I held an inquiry on the 10th inst, as detailed above.

The inquiry was held in the St. Pancras Vestry Hall.

Prof. Robinson, the consulting engineer to the Vestry of St. Pancras, represented the Vestry, who are the owners of the electric light conduits.

Mr. Bassett Hopkins and Mr. Gunyon represented the London County Council, and Mr. Foulger, engineer to the Gas Light and Coke Company, represented his company.

The supply of electrical energy for lighting and other purposes in this district is provided by the St. Pancras Vestry, who are the undertakers under the St. Pancras Electric Lighting Order, 1883.

The greater portion of their system of mains consists of bare copper strip, supported on porcelain insulators, fixed about six feet apart with intermediate distance pieces in a conduit which in general is constructed of brickwork and cement concrete; but in portions at road crossings, or at places where sufficient depth is not obtainble to suit this construction, the conduit is formed by means of a cast-iron pipe eight inches in diameter.

At intervals, which vary according to the requirements of the locality, street boxes or chambers have been made giving access to the mains for purposes of jointing, testing, &c. These are formed of brickwork in cement, and are closed in the usual way with an iron cover filled in with York stone. These street boxes are generally of considerable internal capacity and allow of a man getting into them to effect cross connections or other operations on the mains.

The mains are laid on the three-system and consist of a positive, a negative, and an intermediate main, the pressure between the positive and negative mains being rather over 200, and that between either and the intermediate main, rather over 100 volts.

General Account of Explosions.

It appears that at 12 midnight on the 29th ult., P.C. James Diprose, 436 D, was on duty at the corner of Gower Place and Endsleigh Gardens, and heard the report of an explosion in the direction of the Euston Road. Immediately afterwards a second explosion occurred at the corner of Endsleigh Gardens and Euston Road, which he witnessed, and he saw the cover of the street box at this corner projected about 20 feet into the air. This cover was afterwards found to have been broken. A few yards to the westward, along the Euston Road, he found the cover of another street box displaced about 8 feet, and beyond this again, for a distance of 30 yards, the pavement had been raised over the electric conduit by about 2 inches.

Two men, Charles Govier and David Petrie, sustained injury by these explosions. The former attended the inquiry, and stated that they were walking together along the Euston Road when the first explosion took place; he saw a flash in the ground, was hurled into the air, and came down on his back. He struggled to his knees, when the ground heaved up, probably from the effect of the second explosion, and he was thrown into the gutter.

On getting to his feet he found Petrie in a dazed condition, clinging to the railings. They were assisted to the University Hospital, where their injuries were attended to, and they were able to leave in a short time. The house surgeon's report was stated to be to the effect that Govier had sustained a bruise in his side, and Petrie a sprained ankle—both mild cases.

According to the evidence of Mr. Baron, the chief engineer and manager of the St, Pancras Electric Lighting Station, and from my own inspection, I find that the street boxes in which the explosions occurred were numbered 26A and 27. They are about 10 yards apart, and the conduit between them is an 8-in. iron pipe. The upheaval of pavement took place west of No. 26A, where the brickwork and cement conduit is in use. No external disturbance was apparent above the iron pipe. I had the whole length of this pipe exposed to view, as it appeared to me that possibly electrolytic action might have been in progress from a connection between one of the mains and this short length of pipe, and that this might have damaged service pipes or mains of gas or water in immediate proximity. There was however no trace of any such action.

The brickwork conduit had been seriously damaged, the top being mostly shattered and the bottom cracked to a considerable extent. The length of the portion so damaged is about 30 yards. The whole of this was opened up, and I closely inspected the conductors, but could not discover any sign of electrolytic action or of any electric arc or short circuit having taken place. In fact, these conductors are practically in as good condition as when first laid.

At several of the insulators, more especially in the street boxes, there was an incrustation of a saline material in the vicinity of the negative conductor; this was distinctly damp, and no doubt would cause in the aggregate a serious leak. The tendency to the formation of this incrustation in the case of bare conductors used for electric lighting currents has been observed in several previous cases.

The insulation resistance of this section of the mains was taken by Mr. Thomas, the outdoor inspector, the day after the explosion, and was found to be only 330 ohms for the negative and 110 ohms for the intermediate mains in a short length of about 100 yards.

That such a very low insulation as this is not an exceptional case on this system of mains, is evident from a copy of a report on some tests of mains handed to me by the chief engineer, by which it appears that in May and June last year the insulation of the negative main in sections in or about the Euston Road was found as low as 150 and even 80 ohms, while in other parts very low insulation of this main was found, in one case only 40 ohms.

The chief engineer stated that he smelt coal gas immediately after the explosions in street-box No. 27, in which the second explosion took place.

Mr. Thomas, the ont-door inspector, stated that he smelt a strong smell of gas in a neighbouring street box, No. 26, on the 30th ult., and also on the 31st, when he drew the attention of Mr. Gunyon, engineer to the London County Council, to the smell, who also perceived it.

Edwin Benyon, an electrical jointer in the employ of the vestry, also smelt gas in No. 26 immediately after the explosion.

It appears that the street boxes are systematically examined, for the presence of water or gas, at intervals of from four to six days, and that gas was reported in No. 27 of the 13th ult.

On the other hand, both No. 26A and No. 27 had been examined on the 28th ult., probably about 36 hours before the explosions took place, and were found free from gas, and Mr. Foulger, the engineer to the Gas Light and Coke Company, stated that the tests made by his company since the explosion had failed to indicate any leakage of gas in the neighbourhood; nor could I detect any smell on the 31st ult., or on the day of the inquiry. Since the inquiry, however, Mr. Foulger has informed me that a 4-in. main was found to be leaking on the 9th inst. near the entrance to the London and North-Western Railway, Euston Square, and from information received from the vestry it appears that the position of this leak was about 80 yards from the electric light conduit.

The electric lighting officials admit that they frequently discover accumulations of gas in their street boxes, and the return furnished by the police gives particulars of six explosions, all of which were probably caused by the firing of an explosive mixture of gas and air in connection with the electric lighting mains in St. Pancras.

It has been suggested that in the particular case now under consideration the explosive gas was derived from the sewers, but I do not think this at all a probable explanation.

Mr. Foulger suggested at the inquiry that the gas might have been hydrogen generated by electrolytic action.

This is certainly a more tenable proposition, and I took care to examine the conduits and conductors for any material evidence which might support it. No trace of such action was, however, discoverable.

After careful consideration of the evidence, and of my own investigations I am of opinion that the explosions were caused by the firing of a mixture of coal gas and air by an electric spark.

I account for the presence of the coal gas by leakage from the mains of the Gas Light and Coke Company at one or more points in the vicinity of the electric light conduits; percolation of the escaped gas along the lines of gas and electric mains, which are parallel and in close proximity, where the soil has been frequently disturbed; and entry into the electric conduits and boxes, wherever small openings may exist, which from the construction and materials used will certainly be the case at many points.

The gas would naturally percolate into the open space provided by the electric light conduit, and this would be facilitated to some extent by the small amount of heat produced by the electric current in the mains.

It is probable that since the general adoption of wood pavement, and other forms of pavement which prevent the escape of gas from the soil directly into the open air, the danger of its percolating into underground chambers has been materially increased.

The means provided by the vestry for the immediate escape of any gas from their conduits are, in my opinion, totally inadequate; and even a slight leakage of gas into the conduits would be likely to accumulate until the proportion of gas in the air reached that necessary to form an explosive mixture.

The occurrence of an electric spark was, I think, probably a result of the formation of the salt incrustation on the insulators as mentioned above. This, no doubt, acts to some extent as a conductor, and if a piece break away, a small spark would very likely be caused.

There are many other ways in which an electric spark might have originated, especially with this system of mains, but from my examination I think the cause suggested above the most probable.

It is true that at about the time of the explosions the electrician on duty at the generating station observed a momentary fall of pressure, which probably indicated a sudden rush of current lasting for a very short time, but I am inclined to consider this occurrence as an effect rather than a cause of the explosions, since I could find no trace of any electric arc.

It is possible that the intensely heated gases of the explosions may have allowed of the passage of a considerable current, and a number of partially conducting bridges of solid materials may also have been formed during the progress of the explosion connecting the oppositely charged mains.

The Vestry of St. Pancras should lose no time in removing the two existing causes of danger which I have indicated above, viz., the possibility of an accumulation of coal gas in their conduits, and that of the occurrence of an electric spark at their bare conductor mains.

This system of mains and conduits was selected, I believe, mainly for economical reasons, and no doubt it has advantages in this respect, but these economical advantages must not be reaped at the expense of the safety of the public using the streets.

The vestry were, I understand, advised by Prof. Robinson, after the serious explosion which occurred on January 12th, 1894, in a street box in Endsleigh Gardens, close to the position of the recent explosions, to carry out a system of efficient ventilation wherever possible, and in a report on this accident, which was forwarded to the vestry by the Board of Trade, I also advised this; and further recommended that where possible two small chambers should be substituted for the large ones at present in use as street boxes, and that the low insulation of the negative main, which was then, as now, a very noticeable defect, should be remedied.

Sufficient attention has not, I consider, been paid by the vestry to these recommendations. It was stated by Mr. Baron at the inquiry that there are only 11 ventilating pipes and three ventilating covers to street boxes for a total length of 6½ miles of conduit, and the nearest ventilating pipe was about 300 yards from the scene of the explosion.

None of the large street boxes have, it appears, been divided into two smaller ones, as suggested by me, and the attempts made to remedy the serious leakage on the negative main have not so far been successful.

I am of opinion that the Vestry should immediately provide a thorough system of ventilation, or means for the immediate escape of gas from their conduits and street boxes, should reduce the empty space available for accumulation of gas in their street boxes as far as possible, and should carefully guard against the dangerous formation of an incrustation of salts on the insulators of the negative main by frequent inspection and by protecting these insulators against drip from the condensation of moisture on the iron lids of the street boxes.

I have, &c.,

18th January, 1895. P. CARDEW, *Major*.

LEGAL.

MEDICAL ELECTRICAL INSTITUTE, LIMITED.

ON Friday last, Mr. Henderson again appeared before Mr. Justice Kekewich, and said the company was now represented by counsel. Since his previous application terms had been arrived at, by which the order for a receiver would be discharged, and all further proceedings stayed on terms which counsel had settled, and would supply to the court, liberty being reserved to apply. His Lordship assented.

In the Chancery Division of the High Court of Justice, the same day, before Mr. Justice North, Mr. Everitt, Q.C., appeared on behalf of two sets of debenture holders (Ross and Elers), in support of a motion for the appointment of a receiver and manager of the Medical Electrical Institute, Limited. Mr. Ashton Cross appeared for the company. Mr. Everitt said that the debentures created a general charge on all the property of the company, present and future, including the uncalled capital. There was a provision that the principal money should become immediately payable when the company stopped payment or became insolvent, or when judgment was recovered or distress levied against the company. The company had no money. The shares were almost all issued to shareholders in the old company as fully paid up, and the business had been carried on with the debenture capital. The company had now stopped payment, and the debenture holders had given notice in writing calling in the money which had not been paid. Mr. Justice North: How have they stopped payment? Mr. Everitt said a distress had been put in. It was desired to appoint an interim receiver with power to raise money to pay out the distress, so as to save a sacrifice of the stock. Mr. Justice North: I do not think not paying a debenture is stopping payment. Mr. Everitt said the company said they could not resist the application, and the gentleman he was instructed to ask the court to appoint was a Mr. Hart, the plaintiffs being responsible for his receipts until the security was completed. Mr, Justice North: What is the amount of the first debentures Ross holds? Because I do not think though you sue on behalf of all, you undertake on behalf of all. Mr. Everitt: £1,800 out of £3,000 first debentures have been issued and paid up. Mr. Justice North: How much do you hold? Mr. Everitt: £300. Mr. Justice North: That is not much to undertake upon. Mr. Everitt: It is not, but of course we give security immediately only to enable us to be able to raise the money to the extent of the distress. Mr. Justice North: What is the amount of the distress? Mr. Everitt: £370. Mr. Ashton Cross said he appeared not merely for the company but for first debenture holders to the amount of £1,790 out of a total issue of £2,800, and they were willing to join in the undertaking to be accountable with this gentleman. Mr. Everitt said he had affidavits as to the fitness of Mr. Hart. Mr. Justice North then appointed Mr. Hart receiver and manager of the undertaking of the defendant company to act forthwith, and gave him leave to raise money not exceeding £350. Mr. Ashton Cross mentioned that before Mr. Justice Kekewich, the appointment of a receiver and manager had been obtained over that day on an *ex parte* application. That action was brought by a solicitor who held debentures to the amount of £30, and he (Mr. Cross) was instructed to tender the whole of that debt and costs. Mr. Justice North said he should be prepared to make the order he had made, but he would not do it until he knew what Mr. Justice Kekewich did with that action. Later in the day, Mr. Cross said that Mr. Justice Kekewich had stayed the action before him, and the receiver and manager appointed in that summary way had been ordered to pay his receipts to Mr. Hart. Mr. Justice North thereupon appointed Mr. Hart receiver and manager of the defendant company, on the terms already mentioned.

CORRESPONDENCE.

The Heating Power of Smoke.

My attention has been directed to a criticism which appeared in your issue of 18th ult. on my paper on the "Heating Power of Smoke," which originally appeared in the *Chemical News* of August 3rd, 1894.

I will dispose of the arguments in the order in which they were employed by you, or your contributor. You object to my using Playfair's well-known formula for determining the practical evaporative power of coal, although you admit that you are ignorant of what that formula is, on the ground that it gives incorrect results, and that therefore I am wrong in stating that the total heating value of the volatile constituents cannot exceed 15 per cent. My reason for adopting this formula was, that it is universally known and employed, but if you can give me any better or more reliable formula for apportioning the respective evaporative values of the fixed carbon and volatile matters, I shall gladly apply it to the analysis of the coal, and we shall then see how far my contention is wrong.

I am afraid you have fallen sadly into error in assuming that the conditions which result from stoking green coal into a boiler furnace are, even approximately, identical with those which are obtained when the same coal is distilled in gas retorts. In the former case, a large amount of gas is instantaneously disengaged, and also some vapour of tar, which are, to a great extent, burned into colourless, gaseous products, which are not combustible. The weight of the total visible vapours and soot are but small in proportion, as I have shown in my paper, and this you have not ventured to contradict, either on your own authority or any other. In the latter case, all the world knows that in addition to 10 to 15 gallons of tar per ton of coal there is produced, by close distillation, some 10,000 cubic feet of good combustible gas, but anyone who supposes as you appear to do, that he can secure the heating values of these by stoking coal without the production of smoke, as against stoking with production of smoke, is under a delusion. The question is, therefore, not one of the heating value of tar and combustible gases, as there is but a trifling amount produced in stoking, and analyses of gases taken during the smoky period of combustion show that combustible gases are conspicuous by their absence. With regard to the opinions of the gentlemen you name, in relation to the heating power of gas and tar, I do not suppose that any one would be disposed to call them in question, and I have no doubt I could agree with them in every particular. I am quite willing to accept their opinion as to the heating value of the actual smoke produced in practice, which they can either determine for themselves as I have done, or accept the figures I obtained in my experiments. This is the real point at issue, and not the best way of burning coal, nor of tar and combustible gases if you can get them.

I unhesitatingly affirm, and my statement is supported by the highest authority, that the evaporating value of a given coal, when burned without smoke, is not materially greater than when burned with production of smoke, and if you have anything to say to the contrary, I beg that you will quote something better than popular opinion.

I have no doubt it will help you to correct conclusions in this matter if you will take an exhaustive report of any eminent engineer or expert, in which there is allocated the different ways in which the heat developed by the combustion of the coal in the furnace is expended, and see what room there is left for heat which would be produced if the smoke had been burned. I think you will find that after deducting from the total units of heat which a coal is theoretically capable of developing, the units required for evaporating free water in the fuel, in heating the coal and the air required for its combustion, in heating the excess of air inevitable in practice, in displacing the atmosphere by the products of combustion and replacing with required air, in evaporating the water in the boiler, in radiation and convection, and in ashes and unconsumed fuel, you will find that there is precious little left for the heat of smoke.

With regard to your assumption that I advocated the production of smoke, I refer your readers to my original paper in the *Chemical News*, which, as far as I am aware, is word for word with the leaflet you refer to, and if they can point out that I have used any phrase which could lead any reasonable person to suppose that I was doing so, I shall be glad to hear from them. As long as we have a consumption for domestic purposes alone of some 30 million tons of coal per annum, which, if I am not mistaken, exceeds the amount employed for steam boilers in the United Kingdom, we are likely to have smoke. This is apart from the vast amount of coal consumed in smoke producing furnaces not employed for steam raising. Perhaps it would be better, in your opinion, to await the discovery of some means of preventing the production of all this smoke, than to apply means already at our disposal for preventing its escape into the atmosphere.

I have only to add that my experiments on the heating power of smoke, if they do not convince you, will readily convince such of your readers as are conversant with the smoke question, that my paper does not consist of half-considered statements, as you would have them believe, but that they are the outcome of a careful consideration of only one side of the smoke question, as it was presented to me in my capacity as a member of the Executive Committee of the Glasgow and West of Scotland Smoke Abatement Association.

R. R. Tatlock.

Small Dynamos.

I wish to build a Manchester dynamo, giving 20 ampères 55 volts at a speed of about 1,500, and should feel greatly obliged if you would kindly give me full particulars of the size of the different parts—cores (wrought-iron), yokes (cast), and the amount of wire required to wind them. Would a 2 H.P. gas engine drive this all right?

W. Baisby.

February 1st, 1895.

[To calculate out full particulars of any dynamo in all its dimensions is a work requiring more time than we can spare. Our correspondent would require either to copy a dynamo already made, or get an electrical engineer to work out the sizes for him. We are publishing a series of articles expressly written for amateurs in dynamo construction, and illustrating these articles with the design of a dynamo about 1 horse-power. Using the same methods and rules, our corrrespondent may be able to calculate out sizes for his proposed machine. A 2-horse gas engine should be able to drive it.—Eds. Elec. Rev.]

The Inventor: His Methods and Remuneration.

The writer of the above, in your issue of February 1st, is hardly fair towards inventors. He is not an electrician, that is very clear, or instead of ridiculing inventors and representing them in an almost despicable manner, he would have taken their part and paid a tribute to those who, in telephony, telegraphy, and electric lighting, &c., have made so many magnificent and marvellous presents to the world.

As a rule, I am not an admirer of the "practical manufacturer who, with command of capital, experience, and the assistance of experts, works out a new idea to the finish."

No doubt there are some manufacturers who work their own ideas, but how many are they?

How many of them in their works, real fortresses where nobody penetrates, are using processes and apparatus, and do not care whether they can legitimately do it without paying a royalty to the inventor. "It is only an idea, and so simple! We had thought of it long before," they say; and those men, who would not under any circumstances steal a penny or cheat anybody, deliberately appropriate the inventions which suit their purpose.

The writer of the article has forgotten to speak of the inventors whose patents were purchased by companies which later on went into liquidation before the purchase-money was paid, with the result that the patents were brought under the hammer by other people, and re-sold to a new company, while the inventors lost their patents and were left penniless. Nor does he speak of the companies and the manufacturers who buy stolen patents, and work them under false colours of respectability and honesty!

Before they decide to support an inventor in carrying out his experiments or demonstrations, the capitalist, the company promoter, the manufacturer or the money lender, carefully take the advice of competent and practical men on the value of the new enterprise in which they are interested;

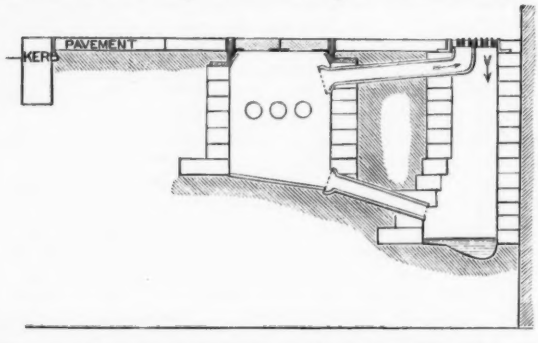
they make their calculations; they know that the profit will be enormous if the enterprise is a success, and if the results are not satisfactory, they will not, after all, lose much money. They have a lien on the patents, or the patents are filed in joint names; they have a first charge on the proceeds of the sale of the patents, and, of course, their share is the lion's share. They have the inventor in their hands; they are never in his hands. The man who has the money is always the master. The inventor must obey; he has duties to fulfil; his master has none. The inventor must work; the speculator can stop the work, discontinue the payment of the annuities, and make the whole thing a wreck. Nobody can compel him to do what he does not like. The inventor has no free hand; he is not even always allowed to work his process in accordance with his notions and knowledge. Sometimes, also, his master nourishes the ambition of being also an inventor; he interferes in a most clumsy manner with the experiments which he conducts, and by changing something round into something square, he considers that he has accomplished an invention, and he also files a patent.

The writer of the incriminated article condescends to say: "Having mildly pilloried the chief types of inventors, it behoves us to say something "respecting the direction in which a man, desiring to place something new before the commercial world, should seek his due remuneration." Inventors do not complain, but they can defend themselves if attacked. Leave them alone! they do not ask anyone's advice, and nobody has any right to intrude and dictate how they must dispose of their invention. It is not mildly that they can pillory the *caste* of those who speculate on their work. If they raise their voice, they will tell sad tales, which will not always be to the credit of the owners of their patents. Our age is justly proud of the progresses realised by its many inventors; one fails to see the object of the unjust, disparaging and abusive curtain lecture on "The Inventor: His Method and Remuneration."

Emile Andreoli.

Explosions.

Referring to my letter to you of 23rd ult., on the question of explosions and their prevention, I am now able to send you a rough sketch of my suggested arrangement, which I beg to enclose, and leave you to deal with as you think fit. I have not given a detailed description, as I do not think it necessary. You will notice that my arrangement works automatically; as soon as gas accumulates in the box it rises to the highest point, which is the top pipe, and from there to the open air through the ventilator, drawing fresh air through the bottom pipe. The bottom pipe acts as the drain for any moisture, &c., and the catchpit can be made wider at the bottom and at any reasonable depth if found necessary.



The ventilator must be fixed on the "building" side of the mains or manhole, as it is impossible to get a *rising* pipe from the *top* of the manhole to the kerb, owing to the slope in the footpaths making the manhole cover higher than the kerb.

B. H. Jenkinson.

Insurance Companies and Jerry Wiring.

Respecting the article in your "Notes" column "Insurance Companies and Jerry Wiring," I should like to offer a few remarks. It is my opinion that the insurance and supply companies are a great deal to blame in the matter. I remember some eight years back a certain gentleman used, in the interest of insurance companies, to personally inspect work in every detail, not merely examining such parts that are thrust upon the notice of any casual observer, but those parts which, for decorative purposes, had to be placed out of sight, such as under floor boards, &c., and was a perfect terror to all evil doers in the shape of jerry wiring. Wherever the work is hidden from view, the jerry wirer makes the most of; he considers himself perfectly justified in getting rid of all short ends and rubbish that has accumulated in his store; anything does, providing he can but get his lamps alight at the completion. He knows full well that the days are not now for the minute inspection recorded above, and perfectly confident that if by chance the latter day fire insurance inspector does come along, a neat looking cut-out box, with glass door, lock and key, &c., or some such article, with a piece of lacquered metal about it, will bring forth the admiration of the visitor for the prettiness of the arrangement. These parts of the installation are always, or should be, in sight, and any fault occurring therein can be instantly detected and remedied; but the vital part of the installation, and that which should have the closest attention, is that which has been hidden from sight, as it is from this that the greatest troubles and dangers will arise. If the insurance companies would but repeat the rigid inspection practised during the early days of electric lighting, the days of the jerry wirer are numbered. Some supply companies now do not insist that their rules and regulations relating to insulation tests be carried out; why, is a matter for conjecture; it may happen that the jerry wirer, with his nasty cheapness, has introduced so much custom, that he has now taken up the position of a great friend to the load curve.

J. W. Manley.

OBITUARY.

George E. Preece.

We deeply regret to announce that Mr. G. E. Preece, brother of Mr. W. H. Preece, C.B., F.R.S., died of cancer in the throat at Colwyn Bay, February 2nd, 1895, having nearly completed his 57th year. He was born at Carnarvon in 1838, and entered the service of the Electric and International Telegraph Company in 1854, and from 1856 to 1861 was attached to the repairing ship, *Monarch*. In the latter year he went to Malta in charge of the Mediterranean cables which formed the commencing link of the present Eastern Telegraph Company's system. He was also employed in laying the cable from Florida to Havana in 1867–8. In 1869 he was connected with the laying of the Persian Gulf cable, and was wrecked in the P. & O. steamer, *Carnatic*, in the Red Sea in September of that year. Subsequently he was employed upon the construction of the French Atlantic, British-Indian, and Falmouth and Gibraltar cables; also was in charge of the manufacture and submersion of the Jersey and Guernsey Company's cables. He joined the Post Office Telegraph Department at the transfer in 1870, but retired in 1878. He was Secretary to the Society of Telegraph Engineers from 1872 to 1876, and his paper on underground work, read before the Society in 1873, was highly appreciated by the profession. In 1884 he joined the firm of Walter T. Glover & Co., and died in its service.

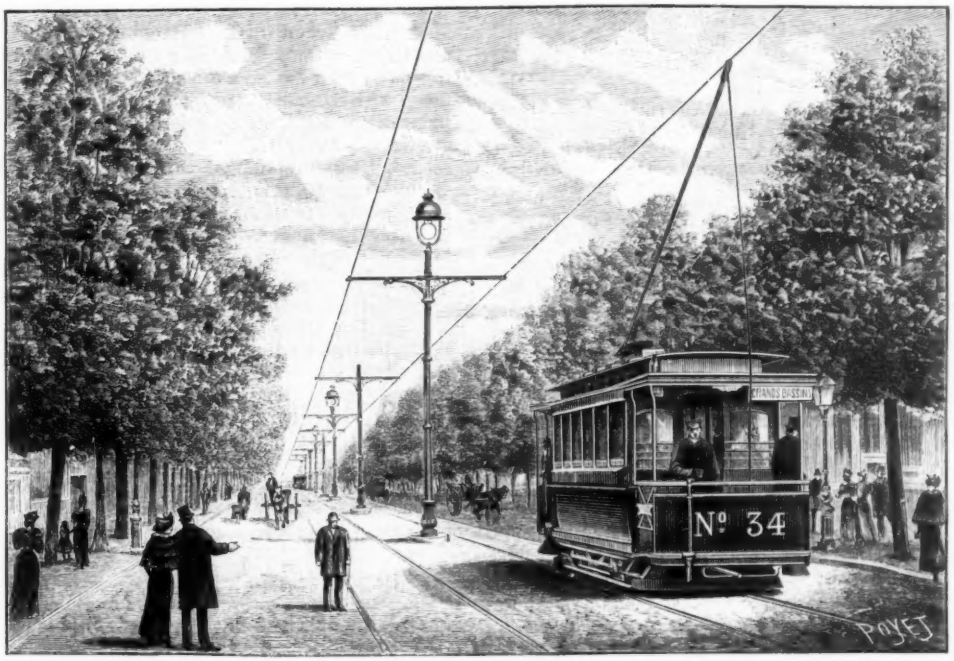
As had been well known to many of his friends, Mr. Preece had been in failing health for some time, and, in consequence, incapacitated from attending to his duties; but all through his illness he had been ever ready and willing to give to his fellow officers such valuable help and information as his long experience, especially in connection with the electrical testing department, enabled him to do.

Mr. Preece was a frequent contributor to the technical journals, especially the Electrical Review and the *Mechanical World*, as well as to the Society of Telegraph Engineers. To the journal of this society, besides the paper mentioned above, he communicated the following:—"Memoir of S. F. B. Morse," "Telegraphic Progress," and "West's India Rubber Cable" (1872); "Comparison between a Minotto and a Leclanché Cell," "Cable Borers," and "False Discharge" (1875). Mr. Preece will also be remembered as former Hon. Sec., first President, and one of the founders of the Northern Society of Electrical Engineers.

He leaves a widow and three children, aged respectively 15, 14, and 8 years with all of whom we sincerely sympathise. The funeral took place on Wednesday last at the South Cemetery, Manchester, and was largely attended, amongst the number being representatives from Messrs. W. T. Glover & Co., the Northern Society of Electrical Engineers, and the Manchester Post Office. Many beautiful wreaths were sent, indications of the warm esteem in which the deceased was held, and of the regret of a large circle of sympathising friends.

THE SPOILERS OF OUR STREETS.

We dedicate the appended illustration of an electric tramway with overhead wires to those enlightened members of



the County Council, who, in the exercise of the office to which it has pleased the ratepayers to call them, opposed last week the introduction of electric traction at Acton. How much a desecration overhead wires really mean may be gathered from this. The thoroughfare is neither Uxbridge Road nor Gray's Inn Road, but is the mere Boulevard de Strasbourg, at Havre. From this and many other views of tramways which we have published, it is impossible to justify the irresponsible opinions of Messrs. Benn, Burns and Co. Had a section of the Progressives properly inquired into the matter and then given a true view of what they had seen, the proposal of the London United Tramways would never have been tabooed. But against ignorance there is no making headway.

Mr. Burns made much use of the Roundhay tramway at Leeds in support of his opinions on the objectionable nature of overhead wires. As a commentary on this, it is interesting to record that the Leeds Town Council have decided to permit further extensions of the overhead wire system. At Rouen, famous for its picturesque streets and beautiful buildings, a concession lasting 50 years has been granted to the tramway company to erect overhead wires, and this after a year's trial of the system.

Still it is little use appealing to a County Council when its sense of beauty is aroused; at all costs they are determined to save Uxbridge Road, with its jerry built houses, from the hands of the electrical spoiler; in the meantime electric traction will proceed elsewhere.

NOTES.

Mr. Henry Wilde's Munificent Gift to Manchester.—At a meeting of the Manchester Literary and Philosophical Society, on Tuesday, a communication was read from Mr. Henry Wilde, F.R.S., the president of the Society, intimating his intention to endow the Society with the sum of £8,000, the annual income from which is to be devoted to various purposes in connection with the society.

The Institution of Civil Engineers.—At the ordinary meeting on Tuesday, February 5th, 1895, Sir Douglas Fox, Vice-President, in the chair, the paper read was on "The Mechanical and Electrical Regulation of Steam Engines," by Mr. John Richardson, M.I.C.E. (of Lincoln).

Obituary.—We are sorry to hear of the death of Mr. John Tasker, who was the pioneer of the telephone and electric light systems of Sheffield. In 1877, he opened a telephone exchange which is said to be the first opened in the provinces. In the year 1886 he, with the aid of others, put down an electric lighting plant to supply part of the town. Two years later the undertaking was purchased by a company formed for the purpose—the Sheffield Telephone Exchange and Electric Light Company—and Mr. Tasker became its chairman. A year or two ago the telephone system was purchased by the National Company, and the Sheffield Electric Light and Power Company, Limited, took up, and still operates, the electric lighting system. Mr. Tasker's death occurred on January 28th, at the age of 75.

Lectures.—The first of a series of lectures by Mr. A. P. Trotter, to the pupils and staff of Messrs. Crompton & Co. was given at Chelmsford on Monday last. The subject was "Accuracies and Errors."

On Wednesday evening last week a lecture entitled "Electricity in Mining," was delivered by Mr. G. R. Peers, A.I.E.E., before the members of the mining class in connection with the Walkden Technical Instruction Committee. Several experiments were made, including electric shot firing, which is now coming into general use in the collieries of the district.

Prof. Carlton Lambert lectured at Guildford on Monday last week, his subject being "Artificial Illumination."

At Cheltenham last week the Corporation electrical engineer (Mr. H. Kilgour) lectured on "Electrical Energy and its Distribution."

The World's Telegraphic and Telephonic Systems.—According to *Journal Telegraphique*, the kilometric lengths of the telegraph and telephone lines of the world at the commencement of the present year are as follows:—State and private telegraphic, 1,459,578; railway telegraphic, 606,918; telephonic, 251,304; total, 2,317,800. Kilometric lengths of telegraph wire:—State and private telegraphic, 4,314,475; railway telegraphic, 1,108,624; telephonic, 1,410,501; total, 6,833,600. Of these totals 259,000 kilometres are cables (representing 262,300 kilometres of wire). The total of telegrams reaches the enormous amount of 351,312,000, an increase of 4·54 per cent. over the total for the preceding year. This message work represents a total receipt of 580,320,000 francs, or an increase of 6·04 per cent. over the total for the preceding year. As regards the length of the telephonic wires, North America has the greatest, with a total of 856,933 kilometres; Germany comes next with 202,600 kilometres, and then Great Britain with 134,215, France following with 94,500. The numbers of telephonic subscribers in the four countries named are: 232,140, 91,921, 69,645, and 26,772 respectively. It may be mentioned that the number of conversations per subscriber per day is greatest in Austria, where the number is 12·4 per cent.; it is 7·3 per cent. in North America, 9·2 per cent. in Germany, 4·8 per cent. in Great Britain, and 3·1 per cent. in France.

The Incandescent Lamp.—A recent issue of the *Electrical World* (New York) contains a sketchy article by a Mr. M. K. Eyre on the processes and operations employed in the construction of the incandescent lamp. The article strikes us as being more suitable for the pages of some magazine perused by the public at large than those of a technical contemporary. Very little information is imparted that would not be perfectly familiar to almost every reader of an electrical journal, and it is only by reading between the lines that a lamp expert can gather anything of an interesting or profitable nature. As a matter of fact, the technical details of lamp manufacture are different in every factory, and such methods and appliances as are described by Mr. Eyre are many of them by no means universally employed. The expert will note, however, with some interest, certain technicalities in use in one of the factories (we believe there are more than one) of the General Electric Company of America, in which the writer, it would appear, is employed. Some of these particulars are as follows:—The material from which the filaments are made is squirted, but the details of the process for making the thread are extremely vague, and scarcely accurate. "A combination of cotton, wood pulp or silk, with sulphuric acid or chloride of zinc," is used to make a liquid compound, "the base and acid" being placed in a vessel and thoroughly stirred. After washing the squirted thread it is wound on to a drum, and when dry, the ends of each coil are measured with a micrometer to ascertain the kind of lamp it is suited to. An elaborate method of "baking" the filaments seems to be in use, viz., placing the blocks in an inner box and surrounding them by a larger one with a layer of plumbago powder between the two. This is a very complicated and uneconomical plan compared with that in use in most factories—packing in one vessel with layers of plumbago powder between the blocks. After "baking," the respective filaments are measured by a micrometer arrangement, and the several sizes sorted into boxes. The leading-in wires—compound copper and platinum—are sealed into short lengths of glass tubing, which again are sealed into the necks of the bulbs on what has been called the re-entrant plan. This is a very usual method in America, but is little used in Europe. The filaments are joined to the platinum wires by means of a carbon paste, a long discarded method, which is again becoming popular in not a few European factories. The exhaustion of the lamps is performed by means of Sprengel pumps, the lamps being attached to the pumps by means of a piece of rubber tube placed over the end of the "exhaust tube," and fitting into mercury cups. This plan, we thought, was quite obsolete. The article concludes with an account of the method of taking photometer readings.

An American Libel Action.—An American senator has just obtained $10,000 damages from the Western Union Telegraph Company for transmitting a telegraphic message containing reflections upon his honesty. The message was signed "Many Republicans," and as the company refused to disclose the names of the senders, an action for libel was instituted against them, with the above-stated result.

The Peripatetic Quack.—The "Professor" from Australia, who is posing as an electro-medical specialist, and about whom we recently published a note, has thought it advisable to change his quarters from a north-western centre to the Plymouth district, where he has commenced a three weeks' exhibition of his "unique" method of electrical treatment. "The deserving poor will be treated without charge." We are sorry to see the Liverpool and Plymouth press so easily deceived as to puff a pretender's methods, which are so "unique" that the electrical press has not been asked to describe them.

The Walker-Wilkins Battery.—The latest communication to the Birmingham *Daily Post* of the 6th inst., relating to this battery, has been brought to our notice, and it simply teems with absolute mis-statements; indeed, we feel much inclined to use a stronger term. The statement that the syndicate owning this "latest development in electrical science" can supply light to customers from the Walker-Wilkins cell at a price not exceeding 8d. per Board of Trade unit, is only true if the syndicate is content to make a dead loss over the transaction. Another assertion that this battery will run for more than 200 consecutive hours, whereas no previous battery of equal capacity would run for more than 10 hours doing the same work, and at the same cost, without a considerable fall of potential force (*sic*), is an unmitigated perversion of the truth. But, as we have said, the whole article is an unblushing puff, written by one evidently entirely ignorant of primary batteries and their uses, and it concludes with the evergreen recovery of the zinc oxide, which not only enormously cheapens the cost of production of the current, but which in itself is of remarkable commercial value. It is high time that Prof. Jamieson turned his attention to contradicting the many wild and misleading statements which are now being circulated in the newspaper press on the strength of his unguarded report on this so-called new element.

The City and St. Pancras Explosions.—Major Cardew's report on the Cannon Street explosion forms very interesting reading, and his conclusions are highly suggestive. The cause of the mishap is clearly attributable to negligence and inattention on the part of the City of London Company's officers to the Board of Trade regulations; indeed, had a telegraph linesman's assistant been in charge of the operations, the explosion would, in all probability, have been avoided. The proportioning of the fuses employed on the mains also come in for deservedly scathing criticism, and the only wonder is that, under the circumstances, matters were not worse. In fact, in all the six questions which Major Cardew set himself the task of elucidating, the answer is directly against the City of London Company's method of carrying out its work. However, with Mr. Frank Bailey in charge, and having Major Cardew's suggestions to guide him, we may hope for freedom from such accidents in the future. To our mind, the gallant Major is not nearly so happy over the St. Pancras upheaval, for his suggestion that the spark which fired the explosive mixture was caused by the breaking away of a piece of the salt incrustration on the insulators does not strike us as being at all likely, and even Major Cardew states that the spark might have occurred in many other ways, *especially with this system of mains*. To assert that the cause, as mentioned, was, in his mind, the most probable, savours too much of guesswork, for surely it would have been easy enough to break away pieces of this incrustation, and so determine experimentally whether sparks were caused or not. The subject of explosions in electric light conduits has been for some weeks past discussed in our correspondence columns; the reading of the two reports to which we refer will, we hope, lead others amongst our readers who have had experience with underground mains to add their views to those already published.

Our Correspondence Columns.—We have been compelled to leave over several interesting communications till next week, through the pressure on our space.

Society of Arts.—On Wednesday, February 13th, at 8 p.m., a lecture on "Light Railways" will be delivered by W. M. Acworth. Sir Benjamin Baker, K.C.M.G., F.R.S., will preside.

Main Box Explosions.—The explosions which have happened during the past week have been two more at Rochester and one at Southwark Bridge. The details are generally the same as with the other explosions.

Personal.—Mr. C. J. Phillips has lately been promoted to the post of assistant engineer to the National Telephone Company. His late staff in No. 1 division have presented him with a handsome gold watch-chain.

The Institution of Electrical Engineers.—On Thursday, February 14th, a paper on "Reversible Regenerative Armatures, and Short Air Space Dynamos," will be read by W. B. Sayers, Associate.

The Northern Society of Electrical Engineers.—Ordinary General Meeting.—At the Palatine Hotel, Hunt's Bank, Manchester, Monday, February 11th, a paper on "Electricity as applied to Mines" will be read by G. S. Corlett, Member of Council.

Society of Engineers. — This Society, on Monday evening, presented the premiums awarded for papers read during the year 1894, viz. :—The president's gold medal to Mr. T. W. Baker for his paper on the "Utilisation of Town Refuse for Generating Steam;" the Bessemer premium to Mr. Ed. C. de Segundo, for his paper on "Power Distribution by Electricity, Water, and Gas."

Fires.—Owing to a fire which occurred on 30th ult. at the electric car depôt of the Birmingham Central Tramway Company, burning down the battery room, the service had to be suspended and omnibuses used instead.

A fire broke out about 3 o'clock on Wednesday afternoon, which resulted in the total destruction of the electric lighting plant at Penarth Dock. The plant was the property of Messrs. J. B. Saunders & Co., of Bute Docks, Cardiff.

North-East Coast Institution of Engineers and Shipbuilders.—At the fifth general meeting, to be held at Newcastle-upon-Tyne on Tuesday, February 12th, 1895, at 7.30 p.m., there will be a discussion on Mr. W. C. Mountain's paper on "The Design and Efficiency of Plant for the Transmission of Power by Electricity," also a paper on "The Application of the Electric Arc to Machinery, Boiler Repairs, &c., will be read by Mr. Henry Foster.

Post Office and the Telephone.—The Commissioners of Sewers have suggested to the Postmaster-General that a select committee of the House of Commons should be appointed to consider the proposed agreements between the Post Office and the telephone company, so that the whole question should be thoroughly investigated. The Commissioners are seeking the support of the County Council, and other municipal bodies, in regard to their petition.

The Institution of Junior Engineers.—At the Westminster Palace Hotel, Victoria Street, on Friday, February 15th, at 8 p.m. precisely, a paper, by Mr. Walter J. Fryer, A.I E.E., member, will be read and discussed: "The Practical Application of Alternating Current Motors." Synopsis: Theoretical aspect of alternating current system of supply in England. Difficulties of working single-phase motors; frequency, dead points, &c. Description of Brown and Oerlikon motors; winding and connection of coils. Application of motor to organ-blowing plant; requirements to be fulfilled, advantages of electrical motors for the work to be performed, automatic clutch pullies, reduction gear, self-starting arrangements, object of condenser and resistances, methods of switching. Several motors will be exhibited, which have been kindly lent by the General Electric Company, and will possibly be working.

Electroscopes in Lecture. — Dr. Oliver J. Lodge writing to *Nature*, says :—"I suppose teachers still use gold leaf electroscopes for their junior lectures; certainly I have found nothing else so dead beat, or so readily understood; and by projecting with a lens a shadow of the leaves on a square-foot translucent screen, the movements are perfectly visible to a large audience by daylight. But the one objection to the instrument, when used for explaining the fundamental facts, say, of induction, is that it indicates similarly positive and negative potentials. Yesterday, however, my assistant, Mr. E. E. Robinson, ingeniously stood the metal-cased instrument on a cake of paraffin wax, and electrified its outside negatively. By this process the zero of deflection is changed; the leaves stand apart for zero potential, diverge more for positive, and collapse for negative. A zero shadow-pointer and rough scale may be readily used; and I propose now to mount a projection electroscope in a suitable slightly-charged Leyden jar, whose outer coat can then be treated as the usual earthed terminal of the instrument, whose case is connected to, or formed by, the inner coat of the jar. The insulated or variable terminal is conveniently arranged as an insulated sphere or other shaped body on the lecture table, not far from the small screen, attached by a long enough thin wire to the leaves—of which it is perhaps best to have only one movable."

BUSINESS NOTICES, &c.

Now Ready.—The Universal Electrical Directory. This well-known Red Book is being issued to subscribers to-day, and a supply will soon be available for those who had not previously placed their orders. It contains a total of 20,958 distinct names of individuals and firms, being 2,500 more than were contained in the book for 1894. In addition to the new names incorporated in the present issue, much financial information has been added; the telegraphic addresses and telephonic numbers are given; and the total of pages added to the work is 80 as compared with that of 1894, making in all about 866 pages entirely of directory matter. The price, as before, is 4s.

Aberystwyth.—With reference to a notice published in our last issue, the Mayor writes us as follows:—"In your last week's issue of the Electrical Review, the following notice appeared. 'Aberystwyth.—The ratepayers the other day discussed the question of the defective lighting of the town.' As Mayor of the Town, it is my duty to refute without delay a statement which by its vague nature is calculated to seriously damage Aberystwyth as a watering place, which we pride ourselves on being one of the best, if not the best, water supplied, drained, paved, and lighted town in the kingdom. Recently we have gone in for electric lighting, and the arc lamps of 2,000 C.P. give the greatest satisfaction and reflect great credit on the firm of Bourne & Grant, who have carried out the work. I therefore call upon you, in common fairness to them, to give an unqualified denial to your notice, and further to publish my letter.—J. D. Harries, F.R.C.S. England, M.R.C.P. Lond., Mayor of Aberystwyth."

Australia.—Ratepayers and others in certain parts of South Australia, Victoria, and New South Wales, are complaining of the cost of the electric light. At Port Augusta the electric light does not pay, and at a meeting held last year the ratepayers resolved to request the council to cut down the expenditure on the electric light to its lowest possible limit. At the Melbourne General Post Office the electric light costs £3,338 per annum, against £2,193 previously for gas. Some of the local papers consider the electric light at Melbourne a "dismal failure." An electric light and power company which has spent there £70,000 upon works, and the last balance sheet showed a loss of £2,000. The unit charge is 8d. and the revenue only 14 per cent. of the amount expended. At Lambton (New South Wales) 6d. per unit is charged and we learn that a "heavy debt" is being incurred. At Tamworth gas formerly cost 12s. 6d. per thousand (or £430 per annum total). The electric light is stated to cost £700 per annum. The plant cost £3,000 and is working to its full capacity and the ratepayers lighting rate has been increased from 4d. to 5d. in the £, and is likely to be still further increased. We give these facts on the authority of an Australian paper.

Belfast.—The First Presbyterian Church, Rosemary Street, was lighted last Sunday evening for the first time by electricity.

Brighton.—The plant of the Brighton Works, which was sold by auction here the other day, is interesting from a technical point of view, the distribution from the very first being by means of high tension. When the station stopped working, its capacity was equal to 16,000 8-C.P. incandescent and 42 nominal 2,000 C.P. arc lamps. The closing scene of the chequered career of this erstwhile promising undertaking was witnessed on Wednesday last, when Messrs. Wheatley Kirk, Price & Goulty sold the entire contents of the station and premises by public auction. The bidding was fairly spirited, buyers being present from long distances, and the prices

realised were considered by those interested as being exceptionally good, the result being in fact more than double the highest offer received by tender, in response to advertisements issued by the receiver.

Dundalk.—The surveyor, with the assistance of a committee, has to prepare a report on the feasibility of certain electric lighting schemes which have been suggested by some of the Commissioners. It is considered that failing the possibility of adopting an extensive scheme, using water-power, they should at least light the Market Square, the Town Hall and that neighbourhood. We believe tenders are also to be invited from parties willing to undertake the lighting of the town for a term of years.

Dundee.—The Dundee Town Council want to borrow £10,000 in connection with their electricity department. The necessary application is to be made.

Eccles.—The Electric Lighting Committee have reported it as their opinion that the time has arrived when the council may safely proceed with a scheme for the electric lighting in the borough.

Edinburgh and Leith.—At a meeting of the Edinburgh and Leith Gas Commissioners on Monday last week reference was made to the probability of explosions occurring in connection with gas and electrical escapes. The Lord Provost said it was right that the Gas Commission should give all the assistance possible in the way of preventing escapes of gas throughout the city. The gas and electric light undertakings must be wrought harmoniously, so that no danger should be incurred. Once they got the electric lighting started, he had no doubt they would all work perfectly well. The Gas Commission, on its part, must do all it could to stop leakages; and the Electrical Committee, on the other hand, must intimate at once to the Commission if in the neighbourhood of its mains leakage was detected or suspected, and must, in addition, exercise the greatest possible care not to break the gas pipes during its operations.

Folkestone.—The area proposed to be lighted under Councillor Baker's scheme has been inspected by Mr. Medhurst, the electrician consulted by the new Electric Lighting Committee, and that gentleman has submitted a scheme to the committee. He estimates the cost of the works he proposes, at £19,000, inclusive of a dust destructor, by means of which he reckons a saving of from £300 to £400 a year would be effected for the borough.

Gloucester.—A handsome building has been erected in George Street, near the railway stations, by the Gloucester Railway Carriage and Waggon Company, Limited, as a showroom for their road vehicle department. The premises consist of two floors, and have been fitted throughout with the electric light. The plant consists of a 10-H.P. nom. Fielding gas engine and 9-unit dynamo, and is placed in a well lighted basement, together with a battery of Crompton-Howell accumulators of 150 amp. hours capacity. The lighting throughout is by incandescent lamps of from 8 to 100-C.P. each, and wherever possible, distributing boards have been arranged for the switches. The whole of the installation, including fixing the engine, has been carried out by Mr. W. A. Walton, of Gloucester.

Hastings.—The account of the Hastings and St. Leonards Electric Light Company for lighting the front line for the quarter ended December 31st, 1894 (£323 11s.), has been referred back by the Town Council for the committee to try to obtain a reduction.

Kendal.—The inhabitants have been circularised regarding the electric lighting question. The Council has received a letter from a Mr. Deacon with reference to utilising the water from the three reservoirs for generating electricity.

Llanelly.—By the casting vote of the chairman the Town Council have decided in favour of lighting the Town Hall, Athenæum, Market Hall, and other public buildings, as well as a portion of the town, by electricity.

Worcester.—The following are the tenders which the County Council propose accepting for the electric lighting of the County Hall:—Verity & Sons, supply of fittings, £91 odd; The New British Electric Installation Company, for wiring the building, £474 odd.

Agency.—Mr. Al. Demaret, of 4, St. Mary Axe, E.C., has been appointed agent for the Westphalian Rolling Mills (Fleitmann, Witte & Co.), of Schwerte, who are large makers of resistance wires.

Bankruptcy.—A Receiving Order has been made at the London Bankruptcy Court against Joseph Torr Todman, electrician, late of 36, Bermondsey Street, S.E.; 11, Queen Victoria Street, E.C., and Rosenfels, Dorking; now of Colombo, Ceylon. The petition was presented by Mr. J. D. B. Lewis, acting on behalf of a creditor, and no particulars transpired with regard to assets or liabilities.

Under a petition presented at the London Bankruptcy Court by Messrs. Crossley & Burn, acting on behalf of the debtor, a receiving order has been made against Walter Andreas, electrical engineer, lately carrying on business at 47a, Lower Belgrave Street, as W. Andreas & Company. The debtor states that he gave up business three months ago, when the landlord seized and sold off everything under a distraint for rent. Since then he has been employed by a firm at Vauxhall Bridge Road. He resides at 132, Hurlingham Road, Fulham, where he has household furniture to the value of £150. The amount of the liabilities did not transpire.

Business Alterations.—The Electrical Accessories Company, Limited, announce that their sole address for works and offices is now at Teddington, Middlesex. We understand that the company has arranged with Messrs. Swinburne & Co., Limited, to rent from them part of their works and the offices previously occupied by them, as they have removed their office and showrooms to 66, Victoria Street, Westminster. The company has found this change necessary owing to the difficulty of dealing with large and heavy work in its present premises, and at Teddington they hope to be in a better position to execute orders. Messrs. Swinburne & Co., will represent the company in London, and will receive enquiries and orders on its behalf at their office in Victoria Street, where they will have samples and stock of goods sold by the company.

Messrs. King, Mendham & Co., of Bristol, announce that Mr. W. B. Allison, of 12, Fenchurch Street, E.C., has ceased to represent them, and all communications should in future be addressed to Bristol.

Change of Address.—Messrs. Scargill & Hanson, electrical engineers, &c., of Bradford, have removed from No. 37, to No. 10, Booth Street.

Correction.—Last week we stated that Messrs. Whitney, Smith & Co. had opened a branch at Nottingham. This should read Whitmy, Smith & Co., of Northampton.

D.P. Storage Batteries.—From Messrs. Johnson and Phillips we have received a revised price list of these batteries; storage battery accessories, and the new D.P. lighting cell are also included in the list. The prices have been reduced in so far as the firm now pay carriage on the accumulators to any part of Great Britain. We understand that they have supplied six miles of these accumulators during the past year. The discharge rates of these cells are now stated to be nearly 20 per cent. better than formerly. The renewal rates are common to the "D.P." or pasted form of cells, *e.g.*, the firm renew either their own or other makers' cells at the same rate.

Electric Hot-Plates for Restaurants. — Messrs. Crompton & Co. are supplying electrical hot-plates to hotels, restaurants, &c., for keeping food warm when supplied to the customer. One restaurant in the West End is now proposing to adopt the system of supplying an electric hot-plate to each customer on which to stand the dishes containing the food. With the usual system the plate gets gradually colder and colder, and the latter part of the course is seldom so satisfactory as the first, but the electric hot-plate rectifies all this. Some restaurant proprietors who do not see their way to supply the hot-plate free to their customers, propose making a charge of 1d. for its use. It is found that a circular hot-plate 8 inches in diameter may be maintained at 212 degrees for an expenditure of 1 ampère at 100 volts. This would cost less than ½d. per hour. There appears to be considerable scope in this direction, and the durability of the plates should be very great, as they are not strained in reaching the above comparatively low temperature. Another system is sometimes adopted—that of using a quick-heating plate which is connected when the order is given. The plate becomes hot in a couple of minutes, and is then used in the same manner as a hot water plate. In the latter case no connecting wires are required on the table, the plates being previously heated from some convenient spot. It is found that the plates retain their heat for a considerable time.

Electric Transmission of Power.—An excellently prepared publication which Messrs. Johnson & Phillips have just brought out, contains an illustrated description of plant for the electric transmission of power which they have laid down in the Sheba mine, which is situated at about 10 miles from Barberton, close to Eureka City. The mine is owned by the Sheba Gold Mining Company, Limited, and is we believe the most celebrated in Africa. New batteries are being put down in the mine, and the power to drive them is to be transmitted by electricity, about five miles underground cable. For utilising the water-power of Queen's River, two turbines of 300 H.P. in the aggregate have been erected to drive the electric generators required for the first portion of the work. The plant consists of dynamos, cables, transformers and electric motors, with all the necessary switching and regulating gear. The book before us contains some very good illustrations of various portions of the plant, also some full page photographs of the works of Messrs. Johnson and Phillips, at Old Charlton, including the machine and erecting shops, winding, cable and cable stranding shops, and testing room.

Hospital Lighting.—The new hospital of the Farnworth Little Hulton and Little Lever Councils is to be lighted by gas, electricity being found too expensive.

Mansion Lighting.—Elveden Hall, in Norfolk, which was recently purchased by Lord Iveagh, has been fitted with a complete electric light installation, comprising some 500 incandescence lamps, two sets of steam engines and dynamos, and a double battery of accumulators. Electric power is also transmitted some distance for working a pump for supplying the house with water. Messrs. Edmundsons, Limited, were the contractors, and the work was carried out to the specification and under the superintendence of Mr. A. A. C. Swinton, as consulting engineer.

Mill Lighting.—The electric light has been introduced into the new addition to Messrs. Charteries & Spence's Rosefield Mills. The plant includes a Siemens compound dynamo of 20 H.P. It is capable of supplying 250 lights of 16 C.P., and is driven by a Chadwick's engine. The dynamo supplies four arc lamps of 2,000 C.P. each, and 154 16-C.P. incandescent lamps. The installation has been carried out by Mr. Donald M'Millan, of Dumfries.

Partnership.—Mr. A. T. Salisbury-Jones announces that owing to increase of business during the last few years, he has taken

into partnership Mr. Guy L. Bidwell, who has been connected with him in various transactions for some years past. The business will therefore be continued as hitherto, under the style of "Salisbury-Jones & Bidwell."

Regulating the Electric Light.—Messrs. Williamson and Joseph are introducing a new system (Davis and Collins's patent) of regulation from high to low candle-power in incandescent lamps at the same time, incurring no waste of current. The amount of current used is proportional to the light given. The extra cost of fitting the regulating system to a house need not be more than 10 per cent. above the ordinary cost. For the present Messrs. Williamson & Joseph are supplying the apparatus for use as pendants (either plain or counter-weight) on brackets and standards, or anywhere where the switch is within reach, and forms part of the fitting. The illustration shows a simple pendant with the regulating switch in the same position as an ordinary tap switch. Ordinary ceiling roses, or standards, may be used, also the ordinary cables and flexible cords of not less than 35/40 strand, and the ordinary shades; the only special fittings required being the patent switch, holder and lamp. The lamp consists of a double-filament lamp, one filament being 16 C.P., and the other 8 C.P., and by means of the switch the following approximate candle powers may be obtained, viz., 2, 8, 16, and 24 C.P.; so that it

will be seen that a range of candle powers is obtained with one lamp and switch, such as could only be obtained in the ordinary way with, at the very least, three lamps and three switches. The switch is so constructed that in the position between either power it is "off." It is also so constructed that either in the "off" position or in the "on" position it is fixed; that is to say, it cannot be partly "on" and partly "off." It will be remembered by our readers that not long ago the electric lighting industry was to be revolutionised by a Mr. Thomas Budworth Sharp who was going to "turn down the electric light" under a patent specification, No. 17,025, of 1893. This patent was recently opposed by Edward Pinder Davis who had secured a patent No. 19,874, 1892, for the same invention. Sir H. Reader Lack, the Comptroller-General of Patents, has now given the following decision which makes Thomas Budworth Sharp's patent void:—"The grant of a patent is opposed on the ground that the invention has been patented on the prior application No. 19,874 A.D. 1892. The applicant did not appear in support of his application at the hearing appointed for the consideration of the case. The applicant's invention consists in arranging a number of incandescent electric lamps or a number of filaments within one lamp so that they may be used in 'parallel' or in 'series' in order to vary the amount of light. It is described in the first part of his specification in a very general manner, and no claim whatever is made for the switch arrangement subsequently described and shown in the drawings. The opponent's invention comprises what appears to be an exactly similar arrangement supplied to a number of filaments which may be in one, or more than one, containing vessel. I am of opinion that the ground of opposition has been established, and I refuse, therefore, to grant a patent upon the application.—Dated January 31st, 1895."

Telephone Between Vienna and Milan.—We understand that the Austrian Government has accepted a proposal made by Italy for a telephone line to be constructed between Vienna and Milan. The line will be ready in the course of this year.

The Britannia Co.—This company, whose works are at Colchester, and London office at 100, Houndsditch, have just issued a new list of engineers' and wood-workers' tools in which will be found a description of some novelties in lathes, as well as of a great number of standard tools for various purposes. The company have been for some time engaged in perfecting an oil engine which they are now putting on the market in the expectation that its merits will win for it a general preference. The engine, which works upon the Otto cycle, is well made and compact, and the working parts are simple and easily got at. It is made in all sizes from ½-H.P. upwards, and is said to be economical and reliable even in the small sizes, and though ordinary petroleum lamp oil is used there is no smell or vapour. The oil is fed to the engine as required by a reciprocating spindle worked off the air valve lever, so that the grooves in the spindle leave a small reservoir and pass into the air passage at the moment when the hot air is sucked through the passage by the engine. The principal feature of the engine is the initial heating of the air before mixing it with the oil by means of the waste heat from the tube lamp, together with the vaporisation of the oil and the further addition of air heated by the waste heat in the exhaust, and so thoroughly is this done that it is (even when using excess oil) practically impossible to make a dirty discharge, the engine for the same reason is remarkably free from soot and tarry deposit. The governing is effected by partially reducing the charge of oil to at least 50 per cent. of full power before cutting out a charge, thus ensuring regularity of running.

Unique Switches.—Mr. A. P. Lundberg has brought out a revised price list of these switches to be attached to his former lists.

W. T. Glover & Co.—This firm announce that they have arranged for Mr. Walter Blenkarn to represent them in the Western, Southern, and Eastern Counties of England. Mr. Hartford, who has hitherto represented them, still continues with the firm, and will take the Northern Counties. We are informed that this addition to the staff has been rendered necessary by the rapid increase of the business.

BOOKS RECEIVED.

The Cyanide Process for the Extraction of Gold. By M. Eissler. Published by Crosby Lockwood & Son.

Elementary Lessons in Electricity and Magnetism. By Silvanus P. Thompson. Published by Macmillans.

CONTRACTS OPEN AND CLOSED.

OPEN.

Islington.—February 13th. Tenders are invited for the supply of alternate-current meters and converters, for the Vestry of St. Mary, Islington. Particulars may be obtained on application to the electrical engineer, 50, Eden Grove, Holloway, N., on or after 13th inst.

Sweden.—February 11th. Tenders are being invited by the Stockholm Gas Works authorities for the supply of a 500 H.P. vertical triple-expansion engine for their central electric lighting station.

CLOSED.

Bristol.—There were seventeen tenders received for the electric light installation at the Guildhall. The following is a list:—

Ball & Co. (accepted)	£438
Waring & Son	440
Fowler, Lancaster & Co.	444
Edison-Swan Co. (Manchester)	444
Willway (Bristol)	463
Palmer „	475
Baker (Newport)	489
Curtis	500
Stock	517
Crompton & Co., Limited	569
Newton	585

There were also higher tenders ranging as follows: £626, £645, £693, £778, £812, and £1,120. The last tender was understood to be from a London firm.

Nelson.—The following tenders were sent in for lighting Stanley Street Chapel, Nelson, with electricity: Spagnoletti and Crookes, Burnley; D. & G. Graham, Glasgow; Berry & Pope, Burnley; Fletcher, Hirst & Co., Burnley; S. J. Waring & Sons, Manchester; E. Scott & Mountain, Newcastle; J. H. Ward & Co.,

Manchester; Maunsell, Mercier & Co., Manchester; Briscoe & Shaw, Blackburn; Manchester Edison-Swan Company, Manchester; Nelson Electrical Engineering Company, Nelson; Calvert & Co., Manchester; Bennett & Druce, Preston; J. Hargreaves, Nelson; Coates Bros., Nelson. The tender of Messrs. Spagnoletti & Crookes was accepted.

CITY NOTES.

The India-Rubber Company's Report.

The report shows the net profit for the year to be £41,961 15s. 9d. Adding £28,952 brought forward, and deducting £25,000 interim dividend paid in July, there remains a disposable balance of £45,913. The directors recommend a dividend of 10s. a share, making, with the interim dividend, a total payment for the year of 10 per cent, and leaving £20,913 to be carried forward.

The report then becomes slightly melancholy, for it says that the trading for the year has been comparatively unsatisfactory. Competition has reduced both the volume of general business and the rate of profit, and there have been but few orders for cables.

The Newcastle and District Electric Lighting Company.

We could never quite understand why this company should affect a singularity in the form of its accounts. It steadily maintains an arrangement very far removed from the Board of Trade ideal. Accounts, however, must be submitted to this Government department in the prescribed form, and for the life of us we do not see why that system should not be adopted in the statement sent out to the shareholders. Of course, anybody can obtain the accounts arranged on the Board of Trade method, on paying a shilling to the secretary; but it means a good deal of trouble to everybody, and, to our mind, gives no advantage to the company. It is impossible to analyse the cost per Board of Trade unit from the accounts before us. It is gratifying to record, however, that there has been a steady increase in the output of the station, the number of units of electrical energy supplied during 1894 being 431,239, against 388,422 sold during 1893.

The gross earnings are £3,792, and after providing for depreciation, and writing off other accounts, the directors recommend a dividend of 3½ per cent. for the half-year, which, with the interim dividend paid in July last, makes 6 per cent. for the year.

The House-to-House Company.

The report of this company shows that though the dividend-paying stage has not yet been reached, good progress has been made during the past year. We need scarcely repeat the conditions which have, to some extent, militated against this company. It suffers, first of all, from being in a purely residential district; and, secondly, it has to pay the penalty of being a pioneer station. Nevertheless, we have to congratulate the company, and especially the manager, on the good results. Particularly do they deserve one's commendation on the substantial decrease in the working expenses, notwithstanding that the lamp connections have increased by 7,429 8-C.P. lamps, and the gross revenue has improved by over £1,600. The demands on our space are so great this week, that we shall defer the analysis of the accounts till next week.

The St. James's and Pall Mall Electric Light Company.

It is very pleasing to be able to record that at all points this company has recovered its former strong position; the balance-sheet is, indeed, one of the best ever presented to the shareholders. It will be remembered that the last report showed some unhealthy features, and the prophets of evil were loud in proclaiming a bad future. The unusual reticence of the company with regard to certain figures almost countenanced such an idea, but we never thought for a moment that there was a possibility of a permanent depression. It was the first rebuff which the company had experienced, and certainly they met it badly. Still that has passed, and we have now the admirable balance-sheet which is to be presented to the meeting of shareholders next week.

It has been become necessary to add to the plant at Carnaby Street, and orders have been given accordingly. To meet this extension, however, it is proposed to issue a part of the £100,000 4 per cent. debenture stock created last year, of which £30,000 has already been issued. It would be surprising to find no reference to law suits in a Pall Mall report, and we observe that an action has been instituted by the Attorney-General, on behalf of the Parish of St. James, alleging a nuisance from the plant at the Mason's Yard station. The difficulties in the way of electrical supply in the West End are enormous.

The net earnings of the company during the year amounted to £13,468. Of this sum, £5,498 was distributed in August last, in payment of an interim dividend at the rate of 4 per cent. per annum for the half-year ending June 30th, 1894, on the ordinary shares, and at 7 per cent. per annum on the preference. £8,090 is left to be dealt with; a dividend of 7 per cent. on the preference shares for the second half of the year, and a dividend of 9 per cent. per annum for the second half-year on the ordinaries, which makes, with the interim dividend, 6½ per cent. for the year.

As we showed by means of a curve last week, the dividend is by no means as good as those which have prevailed in former years, but we repeat that the present balance-sheet points to more settled prospects than previous ones.

The analysis of the accounts, which we publish below, apart from the question of the greater number of units sold, comes out very good, though we notice a considerable increase in the rates and taxes. It appears that the Vestry have revalued the premises, and their decision has been upheld by the Assessment Committee.

Perhaps we shall give in a future issue a set of accounts which have been specially designed to meet the rapacious instincts of Vestries and Assessment Committees. It possesses merit, because it shows how a Vestry may get over the dead centre, and bite its own head off.

	1892.	1893.	1894.
Total capital invested	£185,329	£211,029	£230,000
Number of units sold	1,186,826	1,211,451	1,569,884
Number of lamps connected ...	—	60,037	75,217
Revenue from sale of current ...	£33,397	£29,760	£35,829
Net revenue	—	—	£13,468
Average price obtained per unit..	—	5·89d.	5·47d.

Cost of production.	£		Per unit.
Coal	4,925		·76d.
Oil, waste, water and engine room stores	846		·13d.
Salaries and wages at generating station	4,516		·69d.
Repairs and maintenance of buildings, engines, boilers, dynamos, &c.	2,225	Works cost 1·92d.	·34d.
Rates and taxes	1,673		·26d.
Management expenses, director's remuneration, salaries of managing engineer, secretary, clerks, &c., stationery and printing, general establishment charges, auditors, law charges, and insurance	4,978		·76d.
Depreciation of buildings and plant account	3,695		·56d.
Renewal fund account	—		—
Total	22,858		3·50d.

Revenue.			Average price obtained per unit.
By sale of current	35,829	0 0	5·47
Meter rents	898	6 4	—
Total	£36,727	6 4	

Total cost per unit (exclusive of depreciation and renewal accounts), 2·94d.; works cost, 1·92d.

The Pontypool Electric Light and Power Co., Limited.

We have received a copy of this company's accounts, which, considering the smallness of the concern, are excellent. The capital is only some £6,000, the gross revenue being £724. The number of units supplied to consumers are 25,976, which bring in the sum of £649. By reason of the form in which the accounts are cast, we cannot analyse the cost per unit; but Messrs. Howell, who run the station, have been good enough to furnish us with the following table, which gives the works' cost per unit. In all small undertakings, the proportion to be attributed to salaries is always large; but the extraordinarily small cost of coal is interesting, and goes to show what good management may do, even with few opportunities:—

	£ s. d.	Cost per unit sold.
Coal (119 tons 10 cwt.)	44 19 4	·415
Oil waste, &c.	14 13 10	·278
Water	15 8 2	
Wages and salaries	263 9 3	2·5
Repairs to buildings	2 17 10	
„ boilers	4 2 11	
„ engines and dynamos ...	3 0 0	·257
„ batteries...	10 11 4	
„ mains	15 0 9	
	£374 3 5	3·45

Crowded Out.

We have received a very satisfactory report from the City of Bath Electric Light Company, but we must leave the consideration of it till next week.

The City and South London Railway Company.

An ordinary meeting of this company was held at Winchester House, on Friday last.

Mr. C. Grey Mott, who presided, said that during the past half-year they had made, on the whole, very satisfactory progress. During that time the number of passengers they had carried, exclusive of season ticket holders, had increased by 1,829 over the same period of the previous year. They knew that in the early stages of the line they had a great deal of prejudice to overcome. Since that time they had got rid of a good deal of this prejudice; they had been able to show that the line was perfectly safe, absolutely punctual, the lifts quite safe, and there was no danger whatever from the electrical power. way, had come to live upon it, and formerly where there were rows The result had been that people, finding out the advantages of the rail- of empty houses, they were all occupied, and where one house stood in its own garden, there were now streets of hundreds of houses upon the land. The increase of season ticket holders showed the permanence which they attached to the line. One of the most important and anxious questions with them had been that of the lifts. Of course, an ordinary railway had nothing whatever to do with lifts; on their line, however, nearly the whole of the customers travelled by means of the lifts, and when he told them that since the opening of the line the lifts had gone up and down 2,500,000 times, carrying 25,000,000 of people, they would see what an enormous benefit those lifts afforded to persons using the railway. The lifts involved careful and constant watching; they had over 100 ropes which had to be carefully examined every day, and when they considered that they had had no accident with them, it reflected great credit upon their officers. One of the great advantages of electric traction was that the locomotives required very little attention, and showed very little wear and tear. Many of their locomotives had already run more than 150,000 miles each, and they were practically little or no worse than the day they started. There were, of course, small repairs to be done, but to all intents and purposes they showed very little sign of wear and tear. If they ran a steam locomotive the same number of miles, it would require a great deal of heavy repairs. All this showed the great advantages they derived from electrical working. The chairman then dwelt at great length on the accounts, a summary of which has already appeared in the Electrical Review. The locomotive expenses per train mile, he said, were 6d. against 6·22d. for the previous years; this amount he hoped would still be kept down. The number of trains run during the half-year was 73,208 against 71,143, an increase of 2,055, and the train miles were 230,000, against 224,000. The receipts per train mile had increased from 2s. 0¼d. to 2s. 1¼d. Altogether they had increased their receipts, and decreased their expenditure. When he said that they had increased in the number of passengers, he might have told them that they would have been much larger if they had not raised their fares; they raised the fares some months before, and they sent away tens of thousands of people. The question now was, what were they going to do? It was clear that if they could not carry their passengers, who were residential, into the City between 8 and 10 a.m., they would be compelled to go and reside elsewhere, and the result would be that not only would the company lose those passengers, but also the traffic during the rest of the day, which was now obtained from their families and friends, which formed the mid-day traffic. Therefore it was essential that something should be done in order to provide accommodation for those people, so that they could get in and out to their business every morning. They had increased, as was seen, the number of trains, but under the regulations of the Board of Trade, and under the peculiar circumstances of having a terminal station with two lines of rails converging into it, they could not see their way to increasing the number of trains run, they seemed to have reached the maximum. With the view of increasing the size of the trains, they had been endeavouring to get rid of the locomotive, and to get another carriage upon the train. They were, however, met with very great difficulties, for although it was very easy to put motors on to carriages when they were running on rail-ways in open air, when they had to put it on to carriages which were already down, and which, on account of the size of the tunnels, could not be raised at all, the matter assumed a very different aspect, and it had only been by constant experiment, by great ingenuity on the part of their engineer, that he had devised a system by which, without raising the carriages, he had been able to put underneath the motive power that was required. They had completed a train, and they hoped to run it in the course of a few days. Although by this arrangement they got another carriage on to the train, the whole of the space could not be utilised for passengers; the driver and his assistant had to be provided with room. They got by this arrange-ment about 20 more seats in the whole train. During the hours of 8 and 10 this would accommodate 700 additional passengers. They sent away, by the increase of fares, however, far more than 700 persons. He had little doubt that the future of the line and its dividend-paying power was not to be found in increasing the fares, but it was to be found in carrying at low fares a very large number of passengers. The extra space provided by the rearrangement of the motive power would accommodate 700 more between the hours of 8 a.m. and 10 a.m., but it was quite inadequate. The effect of raising the fare was not satisfactory; it was a very small addition only a ½d., but it showed how careful one must be in in-creasing only to a small degree. It showed clearly to them that they might keep down the traffic temporarily, but could not permanently look to a dividend by that process, and they could only look to good results by fully utilising the line. Except the King William Street Station, all their stations were capable of taking much longer trains, and two or three times as many as they now ran. It was a pity to see a line like theirs only used to the extent of one-third of its capa-capacity simply because of the condition of the King William Street Station. He had always told the shareholders that the directors would not come to them with any proposition for an extension of the line until they were sure that they had such a case as was practically unanswerable. He was afraid their caution had been exercised a little too far, and before they could have any relief the line would have suffered a heavy loss. The directors felt that they could not go on further with the same caution, but he had to tell the shareholders that they ought to proceed at once, under the Act they had obtained, with an important extension of their system. They still proposed to exercise caution, however, inasmuch as they intended only to go as far as Finsbury Pavement—opposite the Moorgate Street Station. They would start from the Borough Station as a branch, in order to get a station close to the London Bridge Station, the Brighton Company having promised to make a connection with its platforms by means of an underground passage. It would also be in connection with the terminus of the proposed Great Northern and City Railway, the prospectus of which had just come out, and which would, he hoped, obtain its money and construct its line, in which case they would have an exchange of traffic with it, so that their passengers would be able to go through on to the Northern system, and they would thus tap the enormous population that lay along the route of that line. Then they would have an underground connection with the Metropolitan at Moorgate Street, and also be not very far off from the Liverpool Street and Broad Street termini. The Central London line had a Bill for a system to go from Bayswater, *viâ* Newgate Street and Cheapside, to a station opposite the Mansion House, and on to Liver-pool Street to the Great Eastern Railway; and it was proposed that they should have a station which would join this company's station at the corner of Lombard Street. Therefore, when these arrange-ments were carried out this company would be in connection with a complete network of railways drawing traffic from every part of London, and have passing its doors almost the entire omnibus service of this great city. He thought no arrangement could have been made better calculated to bring a large amount of traffic. It was believed that the sites could be obtained on terms which would be regarded as highly satisfactory by the shareholders, but, of course, the negotia-tions would take some time. What the directors asked was that the shareholders should give them authority to proceed for the acquisi-tion of those sites for the ultimate purpose of carrying out the ex-tension; but the board did not propose to enter into any agreement involving any large expenditure without the specific authority of the shareholders. They did not ask at the present time for power to create the capital necessary to pay for the acquisition of sites, but to proceed with the negotiations, and then they would want the authority of the shareholders to complete the arrangements.

After a good deal of discussion, an amendment against the pro-posed extension was defeated, and the report was adopted.

The National Telephone Company, Limited.

The report of the directors for the half-year ending December 31st, 1894, to be presented to the shareholders at the fifteenth ordinary general meeting of the company, to be held at the City Terminus Hotel, Cannon Street, London, on Thursday, February 14th, 1895, at 1 o'clock p.m., states that at the extraordinary general meeting of the company held on January 18th, 1894, it was resolved, "That in future two ordinary general meetings be held in each year, and that the directors be requested to take the necessary steps to have the articles of association of the company altered accord-ingly." This is the first occasion upon which it has become the duty of the board to call a half-yearly meeting to present a report and accounts, those for the six months ending December 31st last. In order that a comparison of the state of the business and its general results may be seen, it has been necessary to recast the abstract of accounts given at the foot of the report, so that the half-year now under review may be readily contrasted with that ending December 31st, 1893. The income accrued in respect of the business of the half-year amounts to £378,789 4s., as compared with £337,927 9s. 5d. for the corresponding period of 1893, being an increase of £40,861 14s. 7d. The working expenses for the half-year amount to £205,192 12s. 10d., as compared with £163,853 4s. 10d. for the corresponding period of 1893, being an increase of £41,339 8s. The former figure, however, covers a sum of £15,000 specially set aside to meet the heavy exceptional cost involved in replacing and repairing plant destroyed or damaged by the recent storms. The net result for the half-year (after deducting the Post Office royalties amounting to £34,953 16s. 8d.) is a profit balance of £138,642 14s. 6d., as compared with £142,580 19s. for the corresponding period of 1893, being a decrease of £3,938 4s. 6d., subject, however, to the exceptional provision referred to in the preceding paragraph. The rentals carried forward for unexpired terms of running contracts amount to £313,979 3s. 4d., as compared with £282,948 9s. 5d. at the corresponding period of 1893, or an increase of £31,030 13s. 11d. Out of the available balance of £122,858 2s. 1d. shown by the net revenue account the board will recommend a payment of a dividend at the rate of 6 per cent. per annum on the first and second preference shares, and 5 per cent. per annum on the third preference and ordinary shares. The board also propose to transfer £35,000 to the reserve fund, and to carry forward the balance of £3,579 4s. 7d.

Agreement with the Post Office.—The proprietors were informed in the last report that the more formal agreement necessary to embody all the details involved under the "Heads of Agreement," signed on August 11th, 1892, by the Postmaster-General and the president of the company, on behalf of the respective contracting parties, had

been completed, and that in accordance with a promise of the Postmaster-General it would be laid upon the table of the House of Commons in due course. This was done, but in consequence, as it may be presumed, of the pressure of more important business, the consideration of the agreement by the House was postponed till the present Session. The delay is to be regretted, as it gives rise to a condition of uncertainty in the relations between the Post Office and the company very prejudicial to the development of the telephonic service of the country, and inflicts much loss and inconvenience upon the company and large numbers of its subscribers. It is only right to say that the serious disadvantages of the position have been as far as possible mitigated by the courteous and friendly co-operation of the Post Office authorities, who have shown every disposition to aid the company in minimising the drawbacks resulting from delay.

Further Issue of Debenture Stock.—A reference to the capital account will show that the amount expended upon the construction of exchange, trunk, and private lines for the six months was £134,959 18s. 2d. This class of expenditure is a necessary condition of the expansion of the business in each year, and must be provided for. The board consider that, looking to the wants of the company and the state of the money market, the time has come for a further issue of the 3½ per cent. debenture stock of the company, and they have therefore determined to allot to the ordinary shareholders such an amount of the unissued remainder of this stock at £103 per £100 stock as will represent 15 per cent. of their holdings. The circular giving the details of this allotment, and other necessary papers, accompany this report.

The Liverpool Overhead Railway Company.

THE report of the board of directors of the Livepool Overhead Railway Company, to be presented at the thirteenth ordinary half-yearly general meeting of the shareholders, to be held at the Law Association Rooms, 14, Cook Street, Liverpool, on Tuesday, February 12th, 1895, states that in presenting the half-yearly statement of capital and revenue accounts to December 31st, 1894, the directors have to report that the gross revenue receipts amount to £25,700 19s. 2d., and the working expenses to £17,162 4s. 10d. The number of passengers carried since the opening of the railway was as follows:—

	March 6th to June 30th, 1893.	Half-year ending December 31st, 1893.	Half-year ending June 30th, 1894.	Half-year ending December 31st, 1894.
First class ...	235,487	260,221	277,653	362,179
Second class ...	956,922	1,293,840	1,246,975	2,228,224
Workmen (special return tickets)...	178,333	921,578	1,336,809	1,050,976
Total ...	1,370,742	2,475,639	2,861,437	3,641,379

The increase in the traffic shown by these figures is gratifying to the directors. The increased working expenses are mainly due to the additional train mileage of 70,933 miles due to the opening of the northern extension, and the cost of working the three new stations, at the Nelson and Langton Docks and Seaforth Sands. The traffic on the northern extension has fully answered expectations, and the experience which the directors have thus obtained has determined them to ask the shareholders to approve of the construction of the southern extension, for which the company hold Parliamentary powers.

REVENUE ACCOUNT.

Receipts from passenger traffic amount to ...	£25,336	11 9
Miscellaneous receipts	364	7 5
	£25,700	19 2
Less working expenses	17,162	4 10
	£8,538	14 4
From which deduct		
Interest on debentures and calls paid in advance	2,520	17 7
	£6,017	16 9
Add balance brought forward, June 30th, 1894...	1,248	4 1
Leaving available for dividend	£7,266	0 10

Out of this balance the directors recommend the declaration of dividends at the following rates (less income tax), payable on and after February 16th, viz.:—

5 per cent. per annum on preference shares	£2,428	8 5
2 „ „ ordinary shares	3,750	0 0

leaving a balance of £1,087 12s. 5d. to be carried forward to next half-year.

The Edison & Swan United Electric Light Company, Limited.

AN extraordinary general meeting of the Edison & Swan United Electric Light Company, Limited, was held at the Cannon Street Hotel last Tuesday to pass the resolutions which were given in our issue for January 25th.

Mr. J. STAATS FORBES, who presided at the meeting, said the resolutions were necessary in order to make the articles of association in accordance with the conditions under which the Stock Exchange would grant a quotation.

The resolutions were then put *seriatim* to the meeting and adopted.

After they had been adopted, the CHAIRMAN, in reply to a question as to the business, said they had emerged from protection into the freer air of competition. Competition was something that was supposed to be very good for the public, but not always for the shareholders. He might say that the consequences of competition had not been so disastrous to them as many people predicted. Even in these days of struggle, merit and character were appreciated, and they had succeeded in establishing for their business a certain reputation, the trade mark still had its magic influence. They had been obliged to descend to the arena as regards price, but when the result of the first year's working was submitted, they would not have cause to be greatly depressed.

The proceedings then terminated.

Giant's Causeway, Portrush, and Bush Valley Railway and Tramway Company.

THE directors' report recently submitted to the general meeting of shareholders, which completes the twelfth, records a considerable increase in the receipts during the past year, as compared with those of the year 1893. In the passenger traffic there has been an increase in the number of first class passengers to the extent of 175, and an increase of 6,992 in the number of third class passengers, making a total of 93,917, compared with 86,750 in 1893. The receipts have consequently risen to £2,873 13s. 11d., as compared with £2,730 17s. 2d. in 1893. The goods and mineral traffic fell to 26 tons, from 30 tons in 1893, while the receipts under this head have fallen from £15 5s. 2d. to £12 5s. 1d. during the year. As this traffic was a serious cause of loss in past years, its practical disappearance is not to be regretted. The miscellaneous receipts, and those for parcels, have increased from £27 10s. to £28 7s. 5d., so that the total receipts from the revenue account have been £2,914 6s. 5d., as against £2,782 12s. 4d. in 1893. On the other hand, there has been a considerable increase on the expenditure side of the account, which shows a total of £2,189 8s. 3d., as against £2,048 0s. 1d. in 1893, and £1,720 18s. 10d. in 1892. There is, consequently, a credit balance on the result of the year's working of £724 18s. 2d., as against £734 12s. 3d. in 1893, and £983 17s. 1d. in 1892. The large expenditure on revenue account has been caused, not only by the compensation to the injured lady referred to in our last report, which gives an item of £115, but by an increase of expenditure on the permanent ways and works, from £178 9s. 11d. to £225 6s. 4d.; and especially by the large outlay on steam locomotive repair and renewals, amounting to £363 6s. 11d., as against £104 19s. 5d. in 1893; £300, however, of this has been laid out on a complete renewal of one of the original steam engines purchased in 1883, which is now in excellent order. There has also been an increased outlay on the repairs of cars, viz., £130 2s. 5d., as against £63 17s. 3d. in 1893. All this increased expenditure has been absolutely necessary to enable the directors to compete in future with the annually increasing traffic. While the number of miles run by steam-power during the year has been reduced from 11,664 to 10,487, the cost being 1s. 6d. per mile, those run by electrical power have risen from 18,510 to 20,643, reducing the cost from 4d. to 3½d. per mile. The total number of miles run has increased from 30,174 to 31,130, and the cheapness of electricity as a locomotive power is still strikingly illustrated by the above figures. Lord Kelvin having resigned his seat upon the board, the directors have co-opted Lord Templetown to take his place.

Eastern Telegraph Company, Limited.—The traffic receipts for the month of January amounted to £70,674, as against £64,851 in the corresponding period last year; and those of the Eastern Extension Company to £41.315, as against £39,677 in 1894.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending February 3rd, 1895, amounted to £1,021; week ending February 4th, 1894, £951; increase, £70; total receipts for half-year, 1895, £5,020; corresponding period, 1894, £4,790; increase, £230.

The Cuba Submarine Telegraph Company. The estimated traffic receipts for the month of January were £4,000; as compared with £3,983 in the corresponding month of last year.

The Direct Spanish Telegraph Company, Limited. The estimated receipts for the month of January, 1895, amounted to £1,878, against £1,909 in the corresponding period of last year.

The Great Northern Telegraph Company. The traffic receipts in January, 1895, were £23,200; corresponding month, 1894, £21,000; corresponding month, 1893, £20,800.

The Liverpool Overhead Railway Company. The traffic receipts for the week ending February 3rd, 1895, amounted to £924; corresponding week last year, £632.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending February 1st, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company Limited were £3,279.

SHARE LIST OF ELECTRICAL COMPANIES.

TELEGRAPH AND TELEPHONE COMPANIES.

Present issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1892.	1893.	1894.	Closing Quotation, January 30th.	Closing Quotation February 6th.	Business done during week ended February 6th, 1895. Highest.	Lowest.
173,400£	African Direct Teleg., Ltd., 4 % Deb.	100	...	...	...	101 —104	101 —104	...	...
1,012,880£	Anglo-American Teleg., Ltd.	Stock	£2 15s.	£2 11s.	£2 2s.	41 — 42	40 — 41 xd	40½	40
2,993,560£	Do. do. 6 % Pref.	Stock	£5 10s.	£5 2s.	£4 4s.	77 — 78	75½ — 76½xd	76½	75¾
2,993,560£	Do. do. Defd.	Stock	...	...	...	6½— 7	6½— 7	...	...
130,000	Brazilian Submarine Teleg., Ltd.	10	6½% § §	6½% § §	...	11½— 12	11½— 12	11 15/16	11 11/16
75,000£	Do. do. 5 %, repayable June 1906	100	...	...	...	109 —113	109 —113	...	...
44,000	Chili Telep., Ltd., Nos. 1 to 40,000	5	10%‖ § §	... § §	...	2 — 3	2½— 3½	3	2¾
10,000,000$	Commercial Cable Co.	$100	7 %	7 %	...	147 —152	147 —152	...	...
224,850	Consolidated Telep. Const. and Main., Ltd.	10/-	2 % §	2 % § §	...	1/16— 3/16	1/16— 3/16	...	...
16,000	Cuba Teleg., Ltd.	10	8 %	8 %	8 %	13 — 14	13 — 14	...	...
6,000	Do. 10 % Pref.	10	10 %	10 %	...	20 — 21	20 — 21	20½	...
12,931	Direct Spanish Teleg., Ltd., £4 paid	5	4 %	4 %	...	4 — 4½	4 — 4½	...	...
6,000	Do. do. 10 % Pref.	5	10 %	10 %	...	9½— 10	9½— 10	...	...
30,050£	Do. do. 4½ % Debs of £50, Nos. 1 to 1,600	...	...	...	...	103 —106%	103 —106%	...	...
60,710	Direct United States Cable, Ltd., 1877	20	3½% § §	2¾% § §	...	8½— 9	8½— 9	8 13/16	8¾
400,000	Eastern Teleg., Ltd., Nos. 1 to 400,000	10	6½% § §	6½% § §	...	16⅛— 16⅜	16⅛— 16⅛	16⅛	16⅛
70,000	Do. 6 % Pref.	10	6 % § §	6 % § §	...	17¼— 17¾	17½— 18	17¾	17½
102,100£	Do. 5 % Debs., repay. August, 1899	100	...	...	...	106 —110	104 —106 xd	...	...
1,257,837	Do. 4 % Mort. Deb.	Stock	...	...	...	123 —126	124 —127	125	124
250,000	Eastern Extension, Australasia and China Teleg., Ltd. ...	10	7 %	7 %	...	16½— 16¾	16¾ — 17	17	16⅝
54,100£	Do. 5 % (Aus Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	...	...	...	102 —106	102 —106	...	...
194,300£	Do. do. Bearer, 1,050—3,975 and 4,327—6,400	100	...	...	...	103 —106	103 —106	...	...
320,000£	Do. 4 % Deb. Stock	Stock	...	...	...	123 —126	123 —126 xd	124	...
95,100£	Eastern and South African Teleg., Ltd., 5 % Mort. Deb. 1900 redeem. ann. drgs., Reg. Nos. 1 to 2,343	100	...	...	...	102 —106	102 —106	...	...
129,100£	Do. do. do. to bearer, 2,344 to 5,500	...	...	...	...	103 —106	103 —106	...	...
300,000£	Do. 4 % Mort. Debs. Nos. 1 to 2,016, red. 1909	100	...	...	...	106 —109	106 —109 xd	...	...
200,000£	Do. 4 % Reg. Mt. Debs. (Mauritius Sub.) 1 to 8,000	25	...	...	...	111 —114%	112 —115%	...	...
180,227	Globe Telegraph and Trust, Ltd.	10	4⅛% § §	4⅝% § §	...	9¼— 9½	9⅜— 9⅝	9½	9¼
180,042	Do. do. 6 % Pref.	10	6 % § §	6 % § §	...	16¼— 16½	16⅜— 16⅝	16⅝	16⅜
150,000	Great Northern Teleg. Company of Copenhagen	10	8⅝% § §	8⅝% § §	...	21¾— 22¼	21¾— 22¼	...	...
190,000£	Do. do. do. 5 % Debs.	100	...	...	...	105 —108	105 —108	...	...
17,000	Indo-European Teleg., Ltd.	25	10 %	10 %	...	50 — 52	50 — 52	52	51¼
37,548	London Platino-Brazilian Teleg., Ltd.	10	...	...	...	5 — 7	5 — 7	...	...
100,000£	Do. do. 6 % Debs.	100	...	...	...	105 —109	105 —109	...	...
15,000	Monte Video Teleph. Co., Ord., 1 to 15,000	5	...	...	...	¼— ⅜	¼— ⅜	...	...
28,000	Do. do. 6 % Pref., 1 to 28,000	5	...	...	...	1½— 2½	1½— 2½	...	...
484,597	National Teleph., Ltd., 1 to 438,984	5	5 % §	5 % §	...	5½— 5⅝	5⅝— 5⅝	5⅝	5⅝
15,000	Do. 6 % Cum. 1st Pref.	10	...	...	...	15 — 17	15 — 17	16⅞	16½
15,000	Do. 6 % Cum. 2nd Pref.	10	...	...	...	15 — 16	15 — 16	15 5/16	15¼
119,234	Do. 5 % Non-cum. 3rd Pref., 1 to 90,950	5	...	...	...	6 — 6¼	6 — 6¼	6¼	6
1,100,000£	Do. 3½ % Deb. Stock Red.	...	...	...	...	105 — 107	105 —107	106¾	105½
48,800	New Teleph., Ltd., 25,901 to 74,700; £4 paid	10	...	...	...	... ...	... ...	...	...
171,504	Oriental Teleph. & Elec., Ltd., Nos. 1 to 171,504, fully paid	1	...	...	...	⅜— ⅝	½ — ⅝	...	...
100,000£	Pacific and European Tel., Ltd., 4 % Guar. Debs, 1 to 1,000	100	...	...	...	105 —108	105 —108	...	...
11,839	Reuter's Ltd.	8	5 %	0 %	...	3 — 4	3 — 4	...	...
3,381	Submarine Cables Trust	Cert	...	...	...	118 —123	117 —122	119½	...
58,000	United River Plate Teleph., Ltd.	5	...	...	...	1 — 2	1 — 2	1 1/16	...
146,733£	Do. do. 5 % Debs.	Stock	...	...	...	86 — 91	86 — 91	...	...
15,609	West African Teleg., Ltd., 7,501 to 23,109	10	..	0 %	...	4 — 5	4 — 5	...	...
238,300£	Do. do. do. 5 % Debs.	100	...	...	...	102 —105	102 —105	...	...
30,000	West Coast of America Teleg., Ltd.	10	...	...	...	1½— 2½	1½— 2½	...	...
150,000£	Do. do. do. 8 % Debs., repay. 1902	100	...	...	...	98 —103	98 —103	99	...
64,245	Western and Brazilian Teleg., Ltd.	15	2½%	2½%	...	10⅞— 11¼	10¼— 10⅞	11	10⅝
33,129	Do. do. do. 5 % Cum. Pref. ...	7½	...	...	...	6¼— 6⅝	6⅛— 6⅜	...	...
33,129	Do. do. do. 5 % Def. ...	7½	...	...	...	4¾— 5¼	4¼— 4⅝	4 15/16	4⅝
171,900£	Do. do. do. 6 % Debs. "A." 1910 ...	100	...	...	...	103 —107	100 —104 xd	103½	101
214,890£	Do. 6 % Mort. Debs., series "B," red. Feb. 1910	100	...	...	...	103 —107	100 —104 xd	10 ½	...
88,321	West India and Panama Teleg., Ltd.	10	¼%	⅜%	...	1 — 1¼	1 — 1¼	...	...
34,563	Do. do. do. 6 % 1st Pref. ...	10	...	...	...	10¾— 11¼	10¾— 11¼	11⅛	10 15/16
4,669	Do. do. do. 6 % 2nd Pref. ...	10	...	..	.	9 — 10	9 — 10	...	...
80,000£	Do. do. 5 % Debs. (1917) No. 1 to 1,000	100	...	...	...	108 —111	108 —111	110½	110¼
$1,211,000	Western Union of U. S. Teleg., 7 % 1st Mort. Bonds ...	$1000	...	...	...	115 —120	115 —120	...	...
165,900£	Do. do. 6 % Ster. Bonds.	100	...	...	...	102 — 104	102 —104	...	...

ELECTRICITY SUPPLY COMPANIES.

30,000	Charing Cross and Strand Electy. Supply	5	5 %	4½%	4½%	4¼— 5⅛	5 — 5⅛	...	...
40,000	City of London Elec. Lightg. Co., Ltd., Ord. 40,001—80,000	10	...	...	...	14½— 15½	14 — 15	14 15/16	14⅜
40,000	Do. do. 6 % Cum. Pref., 1 to 40,000	10	6 %	6 %	...	15¼— 15⅝	15¼— 15⅜	15⅝	15 7/16
100,000	Do. 5 % Deb. Stock, Scrip. (iss. at £115) all paid	...	...	...	...	133 —136	133 —136	...	...
56,000	†Liverpool Electric Supply, all paid	5	5 %	5 %	...	7 5/16— 7 7/16	7 5/16— 7 7/16	...	...
49,900	*Metropolitan Electric Supply, Ltd., 101 to 50,000 ...	10	2 %	2½%	...	9¾— 10¼	9¾— 10¼	10 3/16	9 15/16
100,000£	Do. 5% Deb., bonds of £10, £20, £40	...	...	...	...	... — ...	... — ...	...	...
150,000£	Do. 4½% first mortgage debenture stock	...	...	...	...	117 —120	118 —120	118½	...
6,452	Notting Hill Electric Lightg. Co., Ltd.	10	...	...	...	7 — 7⅛	7 — 7⅛	7⅛	...
19,980	St. James's & Pall Mall Elec. Light Co., Ltd., Ord., 101-18,780	5	7¼%	4½%	...	7⅞— 8¼	7⅞— 8¼	7⅞	...
20,000	Do. do. 7 % Pref., 20,081 to 40,080	5	7 %	7 %	...	8⅞— 9¼	8⅞— 9¼	...	...
59,900	*Westminster Electric Supply Corp., Ord., 101 to 60,000 ...	5	3½%	4 %	...	7½— 8	7½— 8	8	7 13/16

* Subject to Founder's Shares. † Quotations on Liverpool Stock Exchange.

‡ Unless otherwise stated all shares are fully paid. ‖ Dividends paid in deferred share warrants, profits being used as capital

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

SHARE LIST OF ELECTRICAL COMPANIES—*Continued.*

ELECTRICAL RAILWAY, MANUFACTURING, AND INDUSTRIAL, COMPANIES.

Present Issue.	NAME.	Stock or Share. ‡	Dividends for the last three years.			Closing Quotation, Jan. 30th.	Closing Quotation, Feb. 6th.	Business done during week ended Feb. 6th, 1895.	
			1892.	1893.	1894.			Highest.	Lowest.
90,000	Brush Elecl. Enging. Co., Ord., 1 to 90,000	3	6 % §	6 % §	...	2⅝ — 2⅞	2⅝ — 2⅞	2⅞	2 1/16
90,000	Do. do. Non-cum. 6 % Pref., 1 to 90,000	2	6 % §	6 % §	...	2⅜ — 2⅝	2⅜ — 2⅝	2 9/16	2⅜
125,000/	Do. do. 4½ % Deb.	Stock	...	...	...	113 —116	115 —118	118	116
630,000/	City and South London Railway	Stock	⅝%	⅝%	1¼%	48 — 50	48 — 50	50	48½
28,180	Crompton & Co., Ltd., 7 % Cum. Pref. Shares, 1 to 28,180	5	7 % §	7 % §	...	3 — 3½	3 — 3½	...	...
50,000/	Do. do. 5 % 1st Mort. Debs., 1—400 of £100, and "A" 1—200 of £50 each	...	...	...	...	102 —107	102 —107	...	...
120,000	Electric Construction, Ltd., 1 to 120,000	2	...	...	...	¼ — ½	¼ — ½	...	...
12,845	Do. do. 7 % Cum. Pref., 1 to 12,845 ...	2	...	...	...	1½ — 2	1½ — 2	...	...
100,000	Elmore's French Patent Cop. Deposg., Ltd., 1 to 66,750 ...	2	*nil*	*nil*	...	1/16 — 3/16	1/16 — 3/16	...	...
91,195	Elmore's Patent Cop. Deposg., Ltd., 1 to 70,000	2	*nil*	*nil*	...	1¼ — 1⅜	1¼ — 1⅜	...	...
69,385	Elmore's Wire Mfg., Ltd., 1 to 69,385, issued at 1 pm. ...	2	*nil*	*nil*	...	1 — 1¼	1 — 1¼	...	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300	5	*nil* §	*nil* §	...	½ — 1½	½ — 1½	...	...
9,600/	Greenwood & Batley, Ltd., 7 % Cum. Pref., 1 to 9,600 ...	10	...	...	...	6½ — 7½	6½ — 7½	...	...
6,837	Henley's (W. T.) Telegraph Works, Ltd., Ord.	10	5 %	5 %	...	9 — 10	9½ — 10½	10½	...
50,000	India-Rubber, Gutta Percha and Teleg. Works, Ltd. ...	10	12½%	12½%	...	24½ — 25½	22 — 23	24½	20¾
200,000/	Do. do. do. 4½ % Deb., 1896	100	...	...	...	102 —104	102 —104	...	...
37,500	†Liverpool Overhead Railway, Ord.	10	...	1 %	...	8½ — 8⅝	8½ — 8⅝	...	...
6,295	† Do. do. Pref., £8 paid	10	...	...	...	13 — 13¼	13 — 13¼	...	...
	Swan United Electric Light, Ltd.	...	10 % §	7½% §	...	... — ...	... — ...	...	...
37,350	Telegraph Constn. and Maintce., Ltd.	12	15 %	20 %	...	41 — 43	41 — 43	42⅞	42
150,000/	Do. do. do. 5 % Bonds, red. 1894	100	...	...	...	104 —107	104 —107	...	...
54,000	Waterloo and City Railway, Nos. 1 to 54,000, £2 paid ...	10	...	...	...	2½ — 2¾	2⅜ — 2⅝	2¾	2⅝

† Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid. ¶ Last dividend paid was 50% for 1890.

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

Crompton & Co.—The dividends paid on the ordinary shares (which have not a Stock Exchange quotation), are as follows: 1892—0%; 1891—7%; 1890—8%.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Birmingham Electric Supply Company, Ordinary of £5 (fully paid), 5¼—5⅝.
Electric Construction Corporation, 6 % Debentures, 93—97.
Electric and General Investment, shares of £5 (£1 paid).
House-to-House Company (£5 paid), 2¼—2¼.
Do. do. 7 % Preference, of £5, 6¼—7.
Do. do. 6 % Debentures of £100, 105—107.
Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid) 7—7¼; 1st Preference Cumulative 6 %, £5 (fully paid), 7—7⅛.
Liverpool Electric Supply, £5 (fully paid), 6⅝—7.
London Electric Supply Corporation, £5 Ordinary, ¼—⅜.
Queen Anne's Mansions Lighting and Heating Company, 6 % £100 Debentures, 99—101.
Yorkshire House-to-House Electricity Company, £5 Ordinary Shares fully paid, 4¼—4⅜.

Bank rate of discount, 2 per cent. (February 22nd, 1894).

PROCEEDINGS OF SOCIETIES.

Institution of Electrical Engineers.

The Origin and Development of the Telephone Switchboard. By J. E. Kingsbury, Associate. Read Thursday, January 24th, 1895.

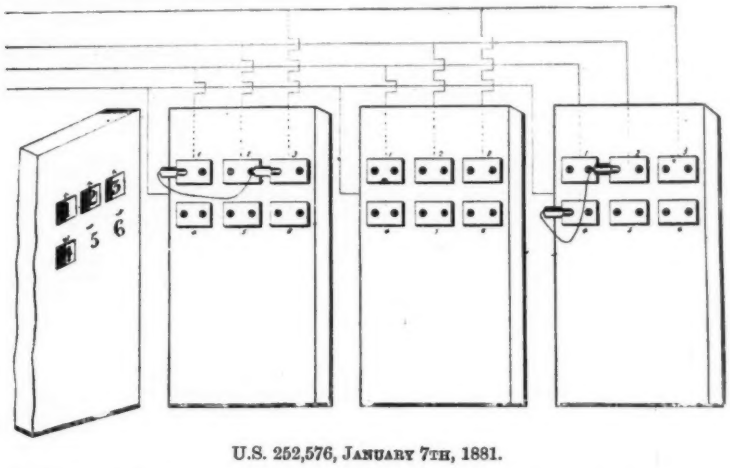
(*Concluded from page* 147.)

For the purpose of illustrating the prior condition of affairs, I will recall attention to the Edison board, which, as I have mentioned, was installed in 1879. About the middle of 1880, when it had probably about 300 subscribers connected, the Edison Company amalgamated with the Bell Company. Some recommendations were then made for alterations in the switching arrangements. It was suggested that the operating should be divided between talking operators and switching operators, as in the Bell board, with the difference that the subscribers' lines should be continued to the talking table. Seventy-five lines were to be assigned to one talking operator, who was to be assisted by two others as switching operators. On the fall of an indicator the talking operator would depress the key pertaining to that line, would ascertain the number required, and then instruct the switching operator to make the required connections. If it should happen to be with a subscriber in another section—say, 200 in the third section—the switching operator would fix the peg in his own board, and then go to No. 3 board, fixing there the proper peg to connect No. 200 of that board with No. 1 of his own, using therefor the special connecting strips set apart for connecting each and every board individually with the other. It was asserted that "by this means an exchange can never become unwieldy." How soon that anticipation became falsified, only those concerned with the practical work of exchanges are able to appreciate. The method of connecting separate boards by special "strips," or bars, was very much improved by "transfer" systems, as they were called when applied to the standard boards; but by dire experience it became evident that the rapidly growing exchanges could not be satisfactorily or economically conducted when there was only one connecting point to a subscriber's line, and when communicating conductors had to be made up by sundry operators to enable a connection to be made.

I will show you an attempt to provide a remedy. It is recorded in a United States patent (No. 252,576), which was filed January 7th, 1881; and from the wording of the specification I gather that the system was in actual use. The subscribers' lines passed through a number of boards (it was on the "Law" system, and easily done). The subscribers' numbers were inscribed on a signal board placed in a central position. These numbers could be obscured by shutters. When a subscriber was put through, the operator would instruct the attendant at the signal board to obstruct the number. On disconnecting, the reverse instructions would be given. Before connecting a line the operator would look at the signal board to see if the subscriber required were disengaged. This method was crude, but none the less deserves commendation as an attempt to overcome the difficulties which were becoming apparent. It is a multiple board without a test system. I cannot claim it as a link in the chain, because, as a matter of fact, the solution of the problem had already been in the Patent Office for over a year. It is in the specification to which I have already called attention—Scribner's, November, 1879. Numerous connecting points, without some prompt and certain means of indicating whether the line were engaged or disengaged, would be a remedy worse than the disease. A triangular conversation would be likely to produce more bad blood than a triangular duel. Now, in November, 1879, the exchange system in London had just commenced. It had certainly had a longer start, and assumed somewhat larger proportions, in the United States, but even there the necessity was not so great as to give rise to the idea which this invention conveys.

The idea is really twofold—firstly, to enable one operator, whilst answering the calls of a given number of subscribers, to connect them with any other subscriber in the exchange without requiring the aid of any other operator or making up any combination circuit; secondly, to inform the operator of the condition of the line with which connection was desired—whether engaged or disengaged. The first part of the idea was attained by increasing the number of spring-jacks indefinitely according to the number of operators required to carry on the work of the exchange. The second part of the idea is really the establishment of an information bureau in connection with every line, the bureau being supplied with information automatically, and giving up its information on demand. Three ways are shown for giving this information: one is a visual signal electro-pneumatically operated; another is the provision of double connecting blocks; the third is that shown in fig. 5, of Scribner 1879, which forms the foundation of the multiple-test system as practically developed. In the diagram (page 146) only the local, or test circuit, is shown. The jack-knife switches illustrate two subscribers on three boards. When a plug is inserted in a jack (as is supposed to be the case in the first one illustrated), a spring, insulated from the blade, and connected with one pole of a battery, is brought into contact with a stud, which is connected by a line to similar studs on every other jack pertaining to the same subscriber. Over the studs are finger keys connected with the other pole of the battery. Depressing the key will close the local circuit and operate

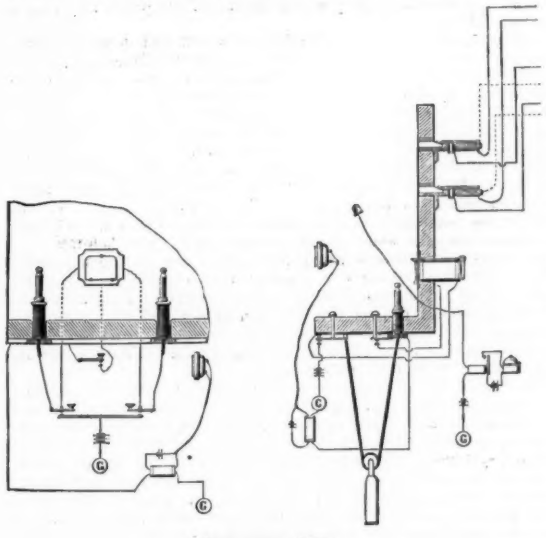
a bell or signalling instrument if the line is engaged, otherwise not. The information required was "engaged" or "disengaged." A local circuit partially closed at one jack would be completely closed by depressing the finger key at another jack of the same line: then the line was engaged. Depressing the finger key at one jack would not close the local circuit unless some other jack of the series had a plug inserted in it: then the line was not engaged. Here was no talking between operators, no passing of calls, or making up of lines. The



U.S. 252,576, January 7th, 1881.

information was obtained as the result of testing a local circuit, and hence the term "test circuit" as applied to multiple switchboards. I believe that the invention in the exact form shown in the 1879 specification was only used in one exchange; but it was the subject of continued experiment and study, and was being systematically developed, so that it might be ready when required. At this stage it had a test circuit entirely distinct from the line, and a test key for each jack. We might reasonably expect that the development would be likely to take the form of simplification, and such was the case.

Before I relate briefly the line of that simplification, I would like to remind you that we are dealing with a comparatively early period of the telephone industry—not too early to appreciate the advantages of metallic circuit lines, as contemporary records show, but a time when the commercial side of the telephone exchange business practically settled the nature of the lines to be run, so that single lines were the rule. It is possible that some may be surprised to hear that metallic circuit multiple boards are provided for in Scribner's 1879 patent, the necessary modifications to the apparatus being clearly described in fig. 11 (page 146) so as to adapt them to metallic circuit use; the plan would not be considered quite satisfactory now, as only one side of the indicator is cut out. At any rate, switchboards were required to be developed for single lines, and this enabled a simplification to be proceeded with. The separate test line gave way to a much more simple contrivance, which was communicated by C. E. Scribner, and patented here on June 22nd, 1883 (No. 3,116).



Scribner, 1883.

To illustrate this improvement, I must again refer to the springjack already described in connection with standard switchboards. It consists of three parts—a frame, a spring, and a contact stud. As a standard board jack the spring is in metallic contact with the frame. To make this jack suitable for use on a multiple board, it is only necessary to insulate the spring from the frame. Place a number of these jacks in a row, connect a subscriber's line with the spring of the first jack—the spring rests on the contact beneath—connect the contact with the spring on the next jack, and you thus have a line through the board which may be broken at any jack. This is the subscriber's line wire, which continues from section to section through the hammer and anvil contacts of the jacks, which contacts are mechanically sustained by the frame, though they are electrically distinct from it. If all the frames of a series of springjacks are connected together by another wire, you have two lines through the board—the subscriber's line and the test line. Insert a plug in any springjack and you break the main line, but connect together electrically the spring and the frame. In other words, the test line becomes a branch of the main line. The main line has an earth on it. Touch the frame of a jack (which is electrically a part of the test line) with a plug forming the extremity of a partial circuit, including a signalling instrument and a battery earthed at one pole, and it will be seen that you complete the test circuit if the line is engaged, and you don't complete it if the line is disengaged. The same result is attained as by the 1879 system, but by a very much simpler arrangement of parts.

Another simplification was made in the apparatus for testing. The finger key contacts on each jack (1879) were so many branches from one side of a battery. Instead of having numerous fixed branches, the same effect could be attained by having one movable branch. This was attained (1883), one separate test plug being provided for each operator. The test plug illustrated is in the form of a thimble, easy of application to the frame of a jack. The drawings show a bell, or buzzer, as a signal, but a "telephone" is suggested as an alternative; and it needed only a slight change to make a still further improvement, by discarding the separate testing plug, making the operator's telephone the signalling instrument, and the connecting plug the testing medium. On touching the frame of a jack with the connecting plug, the operator hears a click in her telephone if the line is already engaged. This method of testing by the operator arrived at the last mentioned stage before the multiple board was put into practical operation in England, and so it remains to-day, although the electrical circuits are very different.

The early multiple boards were very much like overgrown standard boards, the cords being below the keyboard. As then designed the cords were not long enough, and so in the Liverpool boards (the first used in England) the cords were overhead and longer. A board was supplied to the Globe Company, in London, at an earlier date, but the subscribers were not numerous, and I think that the jacks were not multipled, so that we generally regard the Liverpool board as the first in actual commercial use here.

After the Liverpool board an important change was made in the introduction of what is variously called the "local section," or the "answering jacks." The latter term seems preferable, since it corresponds so well to the answering plugs used with them. The Liverpool board was arranged for 200 subscribers to a section, the springjacks being of the Warner pattern, mounted on wood. The jacks being arranged in blocks of 100, placed in numerical order, it will be seen that, taking, for example, the first section, the 200 subscribers' jacks of that section were all at the operator's left hand end of the board, and all three operators had to reach those two jack panels. This difficulty was met by adding yet another jack for each subscriber—the answering jack. These answering jacks were spread out along the board, so that the answering was more promptly done, and an operator had not to reach past another in responding to a call. The arrangement of indicators in relation to jacks was rendered uniform in all sections—a great advantage in changing operators from one section to another. This plan was first introduced in the multiple board shown at the Philadelphia Electrical Exhibition. There was a further modification in the design, which has sometimes been called a "double deck" arrangement. At the top of the board were the general jacks, then the clearing out drops, then a shelf containing half the plugs—one of each pair—then the indicators, below them the answering jacks, then another shelf with the remaining plugs and the keys. This double keyboard arrangement has been retained, but the disadvantage attending the separation of the plugs became speedily apparent. Even so slight a change in the relationship of the plugs slowed down the operating, and their separation also involved a risk of using the wrong plug for completing a connection. The separation of the plugs was therefore abandoned. The plugs were

both placed on the upper shelf, the clearing out drops and the answering jacks changed places, and this arrangement of parts is still retained, except in the branching system where the indicators are at the top of the board and only one keyboard is required.

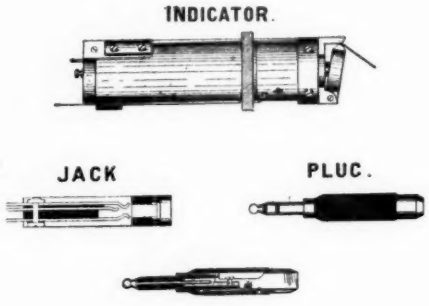
Another problem was met in this 1884 board. Exchanges were growing larger and larger. More subscribers had to be provided for. More springjacks had to be placed on a section, the face of which could not be enlarged. The limitation of size in a multiple section is easily understood. It is the limit of reach of the outstretched arms. That is about 6 feet. The height is a little more variable, as the reach in that direction does not interfere with other operators. If, therefore, it becomes necessary to put an increased number of units in a given area, it can only be done by reducing the size of the units. A reduction in size of parts was then made, and further reductions have since been made. In fact, so far as designs and patterns are concerned, the size has been reduced so as to attain a capacity beyond the requirements of any exchange under existing conditions.

With the reduction in size came a radical change in the method of construction. Instead of each jack being made separately, and then mounted on a base, the base and the jacks were incorporated. Twenty jacks were made into a strip, which was a combination of metal springs and insulating material. This was simply a constructive change, carefully carried out, so as to make no change in the method of operation; the same round plug being used, and the same bush, carefully shaped so as to make the act of testing easy, and the completion of the connection quick. Although various changes in size and construction of parts were introduced after 1884, the general design and the circuits of the board were not materially altered for some years.

During these years the telephone exchange business had been very rapidly extending. Long distance lines were being erected; overhead wires in some places were having such violent hands laid upon them, that burial became necessary; the development of electric lighting and traction, and the production of powerful currents disposed to extend unduly their sphere of influence—all these causes had their effect upon telephone switchboards. Metallic circuit service had to be provided for, and, as the change must necessarily be gradual, mixed service had to be given first. This requirement was met with a minimum of change in existing apparatus. The earth circuit multiple bad in the test wire a line which could be made available as a metallic return by a slight change. The engaged test, as you will recollect, depended upon there being an earth connected to the test circuit. Put an earth on a metallic circuit line when engaged, leave it off when not engaged, and you have the necessary dual condition for negative or positive information. This earth was attached to one or both limbs of the cord circuit, and formed a part of the local circuit, which was completed by the plug in the act of testing. Between the earth and the cord is placed a retardation coil, which prevents currents of high frequency from either entering or leaving the telephone line, but is no bar to the simple battery current required for the test. This may be termed a transition board, but it is a very practicable one.

The importance of accurately balancing the talking lines, as well as the certainty of the test signal, showed the advisability of going back to the original 1879 plan of using a test circuit entirely distinct from the line circuit; and I think that this importance was insisted upon by none more strongly than English telephonists. But here a difficulty presented itself. Experience showed that as the jack contacts in a board increased, so did the troubles due to poor contacts between the line spring and its contact stud. Supposing a 4,000-line board of normal dimensions, on the single or mixed circuit system, there would be 21 jack contacts in the line. To adopt the system of cutting out the indicator with metallic returns, and to employ a separate test circuit as well, would require three contacts in each jack; so that a 2,000-line board of such a character would have 33 jack contacts for each line, or about 50 per cent. more than a single or mixed circuit board of twice its number of subscribers.

With the general improvement in the quality of external lines, it is obvious that it would not do to put into the switchboards apparatus of such a design as would lead to defects in the very portion of the circuit under the electricians' immediate control. This consideration led to another new departure—the last to which I shall call attention—and that is the arrangement of the subscribers' lines in an unbroken circuit throughout the board with no contacts whatever in the jacks, and the automatic restoration of the indicator. The branching of the line contacts and the use of bridging indicators in themselves are no new departure in switchboards. The Post Office used branched line contacts and bridging indicators. It is of interest also to note that their indicators need no manual restoration. But the means by which these results are accomplished are not available for the methods of exchange working generally adopted. New means had to be invented. The idea had been "in the air" for a considerable time, but, as usual, lacked the final touches to make it practicable, like the invention of the telephone itself. I will indicate one of the principal difficulties. Let us suppose that two subscribers are connected, say No. 1 and No. 3,000, the connection being made at No. 1 board. The indicator of No. 3,000 is at the other end of the room. On sending a clearing-out signal, both indicators would drop unless cut out, as in the older system, or prevented in some new way. One of the earliest attempts at meeting this requirement was in Scribner's English patent No. 20,099, December 9th, 1890, which was one of the preliminary steps in the branching system so far as the jack contacts were concerned. The desirability of the separate line for test purposes, however, helped the solution. This test circuit might very well bear an additional burden. The application of a locking device on each indicator, and controlled by a battery in the test circuit, was the first stage. The locking was a necessity; but it is only natural that it should have led to the restoration of the shutter to its normal position, thus rendering another of the switchboard operations automatic. The first design for the circuit of this board was by Mr. Bell, one of the switchboard experts of the Western Electric Company. But, in addition to the Western electric staff, the design of the board was so fully discussed by the switchboard committee appointed by various telephone companies, that I am unable to give, as I should like to do, the individual credit for details.



Branching System.

The indicator springjack and plug are illustrated in the diagram. The indicator consists of two coils mounted on opposite sides of a plate. The longer coil is the operating coil, and it is connected in bridge across the line. The short coil is the restoring part, and is connected in the test circuit. The operating coil, when energised, attracts the armature, to which is attached the arm holding up the shutter. The shutter opens out if the test circuit is incomplete; but if the test circuit is completed by having a plug in any jack of its line, the restoring coil is energised, and the shutter prevented from opening. The springjack has three springs, a bush, and a testing ring. The short spring is the contact for one limb of the line, the bush the contact for the other limb. The two springs of even length are the contacts for the test circuit. The plug has three contact surfaces. The point engages with the short spring, the sleeve makes contact with the bush of the jack, and the ring between the sleeve and the tip connects together the two test springs, thus closing the test circuit and restoring the indicator. The advantage of this construction is that there are no make and break contacts in the jacks whatever, and in this switchboard we reach the highest development, so far, in combining the most perfect talking circuit, a mechanism free from the liability of previously existing troubles, and at the same time a reduction in the manual work.

I will not weary you with a detailed account of the evolution of a springjack, but will be content to direct your attention to one feature—the testing point. In the first plan, Scribner 1879, fig. 5 (page 146), the testing point was a small stud with a key contact. In the Liverpool board the testing point was the front edge of the body of the jack which also formed the channel for the plug (Scribner 1883 diagram). In the Philadelphia Exhibition board (1884), it was still the front edge and the channel for the plug, but no longer the framework. In the branching system it is neither the body of the jack nor the channel for the plug but an additional metallic ring connected with the local circuit by a wire not shown in the diagram, but it still retains the front position because of the prime importance of accessibility.

Comparing 1880 with 1894, it will be observed that in an exchange to which I have already referred having about 300 subscribers, it was considered necessary to provide a minimum of one operator to 25 subscribers. In the latest London switchboard to which I have referred, fitted for over 3,000 subscribers, there is a maximum provision of one operator for 50 subscribers, and in other places on boards of the same system 100 subscribers are attended to by one operator. The number of operators to subscribers is entirely dependent on the load line of the exchange, and there will be necessarily great differences according to the nature and number of the calls. It will therefore be seen that the development in switchboards has followed the general law of enabling more work to be done with less labour.

The latest switchboards fitted in London are on the branching system, and it is needless to say that they contain many features originated by those who have the responsibility of their fitting up and maintenance. I hope the omission of detailed information on these points and many others will not be construed as an absence of recognition of the value of the work done outside the limited number of persons to whom I have referred.

I have advisedly limited this outline sketch to a record of what has been accomplished in the line of switchboards whose merits are to some extent guaranteed by general recognition; and I have also advisedly omitted any reference to complex problems, such as trunking systems between separate exchanges. I do not propose to anticipate the result of experiments now in progress, or presume to speculate on the possibilities of the future, but I would like to be permitted to make one comparison of the present with the past. The progress of telephony has been the subject of some comment. There are differences in that progress, of course. Local circumstances and conditions will mostly account for them, but let us make a comparison without going away from home. Between the setting up of the first and the last telephone switchboards to which I have drawn attention, there has been an interval of 15 years. We are accustomed to regard 1837 as the date of the introduction of the electric telegraph, although, of course, active work in a commercial way had not then, or for some time afterwards, commenced. Fifteen years after 1837 there was no

public telegraphic communication between London and Brighton. The charge for a message of about 100 words to Liverpool was £5. These charges were regarded as high. "But no doubt," says a contemporary record, "these will be diminished when the company's arrangements get more matured, and they are better able to transact any amount of business which may be offered to them. The directors appear to be acting on the policy of checking, rather than encouraging, the use of the telegraph by the public until their establishments are everywhere in perfect working order." Now the most maligned telephone companies have never, I think, been accused of turning away customers. Notwithstanding the novelty of their business, they have been able to invite additions instead of requesting withdrawals. That is undoubtedly largely due to the extent to which the telegraph had prepared the way. Men experienced in the laying of lines and the management of instruments were already obtainable; but there is one direction in which there had been no previous experience of any moment, and that is in the methods and mechanism of inter-communication. The invention of the telephone was defined by judicial authorities as the creation of a new art. The greatest utility of that new art has been found in the development of that means of intercommunication, the exchange system, and the most important feature in the exchange is the switchboard. It has been a very easy task for me to pick out landmarks and put them together to show the route which was probably traversed; but members of this Institution are too familiar with such matters to need reminding that it was by no means so easy a task to devise and manufacture, or set up and maintain in working order, intricate apparatus which should keep ahead of the ever-growing public demand for telephonic communication. I think, however, there can be no doubt that but for the invention and adoption of the multiple switchboard there would be some parallel between telephonic communication now and telegraphic communication at the date I have mentioned: its progress would have been checked by the impossibility of doing the work required.

Discussion.

The President, in proposing a vote of thanks to Mr. Kingsbury for his instructive and carefully arranged paper on a subject of which all of them, he was afraid, knew far too little, said he had to remind them that they owed him an additional vote of thanks for coming forward at a time when they greatly wanted a communication on this subject. It had been a reproach to the Institution for years past that so small an amount of information had been given the members by those individual members who were connected with the telephonic industry, and he thought it was still a reproach that, now they had a paper, it should have come from Mr. Kingsbury, who was practically the representative of a foreign manufacturing company. But that did not lessen their indebtedness to Mr. Kingsbury. He thought the paper was one of those that would always be regarded as a reference paper, the matter in it was so well and so carefully arranged, and it would greatly increase the value of the next number of their *Journal*.

Mr. Phillips said he did not quite agree with the President that anyone should have brought this subject forward other than Mr. Kingsbury. Those of them who were engaged in telephonic work in London would all agree that there was no one so competent in the kingdom as Mr. Kingsbury to illustrate the special subject he had taken, the origin and development of the switchboard, because there was no one in the country who knew so much of that particular branch of telephonic work. There was one point he wished to draw attention to in the description of the Edison board. Mr. Kingsbury said the subscribers were left to ring each other up. That was, he believed, the original design of the board, but very soon after its use that particular board was greatly improved upon. If they looked at the sketch they would see two solid black dots near the top of the board, representing pegs connecting two subscribers together; if a third peg were inserted between one of the vertical strips and the horizontal strip, No. 7, which was connected with the instrument, that put the operator's telephone in connection with both subscribers' lines, and the act of turning the handle would, of course, ring up both subscribers. He thought there was a slight fallacy in the point where Mr. Kingsbury said two blades of grass were growing where but one grew before. He did not quite follow that. In the Bell board they had two operators, one to do the plugging, and the other the talking. In the Edison board they had only one operator—that was, until the exchange grew rather large one operator had to do the whole of the work, and that was one point which led to the preference in the beginning for the Edison board over the Bell board. It was a very great feature in the switchboard to give the operator the sole control over the connection; if she were dependent on someone else doing it, she never knew whether that other had done what she desired or not, whereas if it were all in her own hands she would have no doubt about it. The actual work done was rather less on the Edison board than on the Bell board, because if one operator had to do the two operations, she had first of all to pick up her cord from somewhere—usually it was kept round the neck; in the Edison board it was only necessary to take the plug from the earth strip and put it in the horizontal cross connecting strip. Mr. Kingsbury had described all these things so well, that there was not much to be said on the subject. With regard to the multiple switchboard, the author was quite right in insisting on the importance of the development of that switchboard. There was not the slightest doubt that was the great feature in the history of the board, and which had enabled large numbers of subscribers to be dealt with. Everything that could be done to save the smallest possible amount of time in a telephonic exchange was of the utmost importance. The telephone service was made up of a great number of details, and the saving of a few seconds in each connection meant the saving of a certain definite amount of time each day. In connection with the multiple board, he might say that in London they had a multiple board before the Liverpool board was used, a board invented by Mr. Hawes, who was at that time in the service of the United Telephone Company. It was invented entirely independently of the American board, of which nothing was known at the time, and it was worked for two or three years in the Chancery Lane Exchange. It was rather peculiar in construction, inasmuch as the jacks were placed vertically, and the plugs placed in that position instead of horizontally. It formed a long table with a box-like trough, and it was known as the "Hawes trough." The branching system was undoubtedly a great improvement an anything they had had before. It came very opportunely, when they were all looking for something of the sort, and, so far as they had had experience of it, it worked very well. It had only been working from the first Monday in August, but he believed it went very well from the first. There was one point in regard to which he differed from Mr. Kingsbury, and that was where he said the transition board was a very practical one. That was a point upon which they had differed for some considerable time, and he thought he might draw his attention to the fact that he said earlier in his paper, that leaving one indicator as a branch on the line when a connection was made was a very undesirable feature; he was very glad to see that Mr. Kingsbury had arrived at that conclusion.

Mr. Hawes said the idea of his board, to which Mr. Phillips had referred, in putting the board vertically and the jacks horizontally, was to allow of more operators working in each section. That was a great advantage; but a disadvantage was that the dust got in between the contacts and insulated the lines occasionally. With regard to the comparison Mr. Kingsbury had drawn between the Edison and Bell boards, or between cord and plug boards, the chief disadvantage of the Bell boards in those days was that they could not get good cords. If Mr. Kingsbury, in his reply, would refer to the present form of cords, he would doubtless be able to give them some useful information. The branching system was an immense advance on the old system, and more attention might have been given to it with advantage.

(To be continued.)

THE EXPLOSION ON SOUTHWARK BRIDGE

Last Friday afternoon an explosion occurred in one of the City Company's junction boxes on Southwark Bridge. A portion of the pavement was blown up, and two or three passers by were injured.

An inquiry into the circumstances of the above explosion was held by Major Cardew, on Monday, at the Guildhall.

Mr. H. Homewood Crawford (City Solicitor) appeared for the Corporation, the trustees of the Bridge House Estates, who own Southwark Bridge; and he also represented Lieutenant-Colonel H. Smith (Commissioner of City Police). The City of London Electric Lighting Company, Limited, was represented by Mr. F. Bailey (chief engineer), and the South Metropolitan Gas Company, Limited, by Mr. George Livesey (chief engineer).

Police-constable Sawyer said that about 1.50 p.m. on the day of the accident he was on the west side of Southwark Bridge, going north, when he heard an explosion behind him. As he was turning round another occurred. He saw three clouds of smoke rising and a man blown into the air several feet. He afterwards took the man to Guy's Hospital.

Miss Florence Heath, residing at South Hampstead, stated that when walking about half-way across the bridge from the City she saw a cloud of smoke on the west side at the south end, and heard a loud report. This was followed by another explosion just in front of her, with blue smoke, accompanied by the displacement of flagstones. When turning round she heard another explosion. She saw a man being pulled out of a hole caused by the explosion near the City end of the bridge.

Several other witnesses gave corroborative evidence, and one of these (Mr. W. C. Palmer) added that he saw several flagstones thrown up into the air three or four feet and a woman knocked over. Almost directly afterwards the cover of a street box on the other side of the bridge blew up with a loud report, accompanied by some light blue smoke.

Police-inspector Eve said that shortly after 2 p.m. on the day in question he was on the bridge with officials of the electric lighting company. They went to the iron box lid at the south east corner and lifted it. There was a strong smell of gas from the box, which contained a gas meter. They then went to a similar box with a meter on the west side, where there was also a strong smell of gas. He at once despatched a constable to give information to the officers of the gas company.

Mr. W. Cupid, outdoor foreman to the South Metropolitan Gas Company, said about 3 o'clock on the afternoon of the accident he opened the road at the south-west corner of the bridge, and found a 3-inch main cracked about half way round and split lengthways about six inches. The crack was about the thickness of a sheet of paper. It was centrally over a culvert which passed across the roadway. The main passed about an inch above the electric mains.

In reply to the City solicitor, he said the crack round the pipe might have been leaking two or three days, or it might have been caused by the explosion.

Mr. R. Thompson, in the service of the electric lighting company, said he last examined the boxes on the bridge on the 25th, and there was no smell of gas in them then. Mr J. P. Buck, superintendent of street work for the electric lighting company, said that when the explosion was reported to him he went to the bridge and found a strong smell of gas coming from the manhole and the gratings. The electric mains were uninjured except for a few dents caused by

stones. Twelve men were constantly employed in searching for gas in the electric light boxes.

Mr. T. Blythe, foreman to Messrs. Mowlem & Co., said in January last his employers were engaged by the City Architect to carry out the construction of new gullies on the bridge—one on the east side and one on the west side at the south end of the bridge. He cut away the brickwork from the old grating above the culvert and close to the gas pipe, but he did not touch it. The particular part of the pipe found cracked they did not go near. He thought the frost and rain might have caused the crack in the pipe owing to its being so close to the surface.

Mr. F. H. Jackson, in charge of the electric lighting company's machinery, produced an automatic voltmeter record showing that at the time of the explosion there was no record of any disturbance at the company's works.

Mr. Livesey said it was impossible to prevent all escapes of gas. They had many difficulties to contend with in connection with this matter. One of these was the heavy steam rollers. Although their mains had, to a great extent, been placed deeper since these were brought into use, the company could not relay the whole of their mains, as that would mean taking up all the streets in South London. Then the sewers were laid underneath their mains, and pipes were sometimes broken in this way. He could not suggest any reason for the explosion. Generally when there was an accident of the kind they were able to trace a light to somewhere, but in this case they were unable to do so.

The proceedings then terminated.

NEW PATENTS—1894.

1,385. "Improvements in galvanic batteries." H. Tipping. Dated January 21st.

1,405. "Improvements in electric arc lamps." L. Barriere. Dated January 21st.

1,436. "Improvements in and relating to pillars or posts for electric lighting, carrying electric wires, railway signals, and the like." J. B. Millar, of the firm of George Smith & Co. Dated January 22nd.

1,442. "Improvements in electrical ceiling roses." C. L. Clarke and W. P. Theermann. Dated January 22nd.

1,446. "Improvements in galvanic batteries." C. B. Schoenmehl and C. M. Platt. Dated January 22nd. (*Complete.*)

1,474. "Electro-magnetic brakes." J. Hopkinson. Dated January 22nd.

1,477. "Improvements in feeding mechanism for electric arc lamps." H. Bevis and G. Binswanger. Dated January 22nd.

1,478. "An improved insulated support for electrical conductors." H. Hirst. Dated January 22nd.

1,504. "Improvements in coin-controlled apparatus for producing various electrical phenomena or effects." W. P. Thompson. (Communicated by J. L. Ketcher, United States.) Dated January 22nd. (*Complete.*)

1,512. "Improvements in electric arc lamps." Sir C. H. A. F. L. Ross, bart. Dated January 22nd.

1,526. "Underground conduit for electric roads." E. A. Mathers. Dated January 22nd. (*Complete.*)

1,536. "Improvements in or in connection with alternating current electric motors." Brown, Boveri & Co. Dated January 22nd. [Date applied for under Patents, &c., Act, 1883, Section 103, July 3rd 1894, being date of application in Switzerland.]

1,544. "Improvements in and relating to electrical conductors." E. D. Lewis. Dated January 22nd. (*Complete.*)

1,546. "An electric switch." F. Wright and E. J. Piper. Dated January 23rd. (*Complete.*)

1,550. "Improvements in electrical switches." C. L. Clarke and W. P. Theermann. Dated January 23rd.

1,558. "Improvements in ceiling roses and other similar electric fittings." J. G. Williams and H. M. Darrah. Dated January 23rd.

1,587. "Improvements in or appertaining to electrical clocks, bells, indicators, and similar instruments." F. Hope-Jones and G. B. Bowell. Dated January 23rd.

1,611. "Improvements in and connected with the electric lighting and heating, and also the ventilation of railway carriages and other vehicles." E. J. Preston, of the firm of J. Stone & Co., and A. B. Gill. Dated January 23rd.

1,649. "Gas engines, ignition by electricity." H. Crane, jun. Dated January 24th.

1,676. "Improvements in electrical storage batteries." T. B. Marchant and J. Woolley. Dated January 24th.

1,697. "Improvements in and connected with arc lamps." H. Niewerth and R. Niewerth. Dated January 24th.

1,698. "Improvements in electric current regulators." H. Niewerth and R. Niewerth. Dated January 24th.

1,707. "Electric water-gas." J. H. Dunn and J. Parsons. Dated January 24th.

1,710. "Safety fixing for the various decoration covers and lamp holders for electric light fittings." F. J. Curley. Dated January 24th.

1,714. "An improvement in electrical glow lamps." Siemens Bros. & Co., Ltd. (Communicated by Messrs. Siemens & Halske, Germany.) Dated January 24th.

1,717. "Improvements in and relating to electric accumulators." O. Pirsch. Dated January 24th.

1,730. "Improvements in electrical devices for lighting cigars, or for other like purposes." H. Edmunds. Dated January 24th.

1,731. "Improvements in secondary batteries." C. A. Faure and F. King. Dated January 24th.

1,744. "Improvements in microphones or telephone transmitters." C. M. Stead and L. W. Douthwaite, trading as the Electrical Mechanical Agency Company. Dated January 25th.

1,788. "Improvements in apparatus for the manufacture electrolytically of tubes and other articles of circular section." F. E. Elmore. Dated January 25th.

1,797. "Improvements in filaments and carbons for electric lamps." P. Stiens. Dated January 25th.

1,824. "Improvements in watt-meters." J. Perry. Dated January 26th.

1,835. "Improvements in electric exploders." H. V. Keeson. Dated January 26th.

1,840. "An improved carbon transmitter or microphone." G. A. Nussbaum. Dated January 26th.

1,854. "Improvements in electric burglar alarms for doors." G. R. Blackburn. Dated January 26th.

1,867. "Improvements in shade holders for electric, gas, or other lights." W. E. Gibson and H. Hirst. Dated January 26th.

1,885. "Improvements in insulating devices or attachments for electric wires." A. H. Weikman. Dated January 26th.

1,899. "Improvements in connection with electric railways or tramways." E. Mapple. Dated January 26th.

1,906. "Improvements in electric condensers." G. Threlfall. (Communicated by R. Threlfall, Australia.) Dated January 26th.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1894.

4,539. "A joint for wires and electrical conductors." W. Diesel-horst and Siemens Bros. & Co., Ltd. Dated March 3rd. Claim:—A joint for wires or electrical conductors consisting of a pair of sockets screwed together bored taper each way and containing divided taper plugs urged apart by a spring and grooved to receive the wires or conductors between their halves, substantially as described.

7,119. "Improvements in and relating to speed and power regulators for motors." H. B. Gale. Dated April 10th. The inventor employs as a means of storing energy, any suitable form of electrical storage battery, and as the moving or revolving body, which replaces the fly-wheel of the older constructions, the armature of a dynamo-electric machine, constructed and connected to the storage battery, so that when revolving with the desired speed in a constant direction it may act either as a generator, absorbing surplus energy from the motor and charging the battery, or as an auxiliary motor drawing energy from the battery and assisting the engine or prime mover, at times when the load exceeds the average.

7,322. "An improved electric central alarm or call apparatus." C. Christgau. Dated April 12th. Relates to an electric alarm or call apparatus for hotels and similar institutions, the object of which is to operate a bell or bells in a certain room or rooms from a central clock at four short intervals at any desired time or at various times. 1 claim.

8,761. "Improvements in and connected with electric fire alarms." A. Archibald and G. Tarry. Dated May 3rd. Claim:—In electric fire alarms the method of holding and insulating the fusible metal plug substantially as described and shown.

10,171. "Improvements relating to writing telegraphs." P. A. Newton. (Communicated from abroad by Elisha Gray, of America.) Dated May 25th. Relates to a means for storing, as near as practicable to the point of application to the receiving pen, of the force to drive it, in such a way, that the force shall be practically instantaneous in its action. 11 claims.

12,137. "Improvements connected with a combined walking stick and electric lamp appliances." H. Newbold. Dated June 22nd. Relates to fitting an electric lamp with a primary battery or accumulator in a walking stick, and to providing the head or the knob of the stick with an automatic actioned contact maker in order that electrical contact can be made on the head or knob being released and springing up under the action of an enclosed spring, and for breaking contact when the head or knob is returned by pressure. 1 claim.

12,875. "Improved alternating current meter and method of measuring alternating currents." J. F. Kelly and W. Stanley. Dated July 3rd. Relates respectively to the art of and to the class of apparatus employed for measuring and indicating the amount of current passing over a given circuit, and has for its objects to provide a reliable method of and a simple means for measuring currents of the alternating class. 6 claims.

12,605. "Improvements in or in connection with long distance telephones." W. A. Nikolajczuk. Dated June 28th. Consists in the use of periodic currents which are produced in the transmitter and cause a variation of the current strength of a source of current by means of a liquid-rheostal, which is situated in an exchange station and is conductively connected with the receiver. The currents produced by varying the resistance in the auxiliary current source are then converted by the receiver periodically, and according to the transmitter currents into sound waves. 3 claims.